

THREE ESSAYS ON TAXATION AND MACROECONOMIC DYNAMICS

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an meine Eltern und meinen Bruder

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ABSTRACT

This thesis analyzes how the configuration of a country's tax system – or a change to that system – can affect dynamics of macroeconomic aggregates in New-Keynesian Dynamic Stochastic General Equilibrium models. It contains three essays, each having a primary focus on the Euro Area and each addressing a policy-relevant question. The thesis covers classic topics like fiscal multipliers and Liability-Side Equivalence as well as the more recent subject of Fiscal Devaluations.

The first essay analyzes the impact of changes in the value-added tax (VAT) on output. The innovation relative to previous theoretical contributions on this subject is that my model accounts for empirically observed tax pass-through dynamics. I find that the introduction of empirically plausible VAT pass-through dramatically lowers short-run multipliers relative to those obtained if tax pass-through is not rigorously modeled. By showing that workhorse models used in academic and institutional research overestimate the short-run impact of VAT changes, the work might help to improve model-based guidance on the design of discretionary fiscal policy packages.

The second essay addresses Fiscal Devaluations, a policy that is aimed at deteriorating the real exchange rate – and thereby improving a country's competitiveness – absent an adjustable nominal exchange rate. It prescribes a reduction in social security contributions financed by an increase in the VAT. The higher VAT increases the price for imported goods, while the reduction in social security contributions (which lowers marginal production costs and with it producer prices) makes domestic goods cheaper in the importing countries. In the co-authored paper, we analyze the impact of a Fiscal Devaluation jointly undertaken by Europe's periphery countries. The novelty is that our model features nominal wage rigidity – which is shown to be crucial for the policy's effectiveness – and that we compare two types of Fiscal Devaluations, one that reduces firms' social security contributions and one that lowers workers' contributions. We find that the former type is considerably more effective than the latter type.

The third essay investigates Liability-Side Equivalence in the context of social security contributions. This principle implies that the statutory split of contributions between firms and workers does not matter for the real allocation in the long run. I contradict this notion by showing that it matters for macroeconomic fluctuations, for the efficiency of the allocation, and thereby for long-run productivity in my model. The only non-standard assumption required to generate this result is that the social security system runs a balanced budget.

ZUSAMMENFASSUNG

Diese Dissertation untersucht, wie sich die Ausgestaltung eines Steuersystems – bzw. dessen Änderungen – auf die Dynamik von makroökonomischen Variablen auswirken kann. Die Analyse wird mit Hilfe von allgemeinen Gleichgewichtsmodellen durchgeführt, die Keynesianische Eigenschaften haben und durch die Berücksichtigung von stochastischen Elementen dynamisch sind. Die Arbeit umfasst drei Essays, deren Hauptfokus auf der Eurozone liegt und die politikrelevanten Fragestellungen gewidmet sind. Die Arbeit deckt klassische Themen wie fiskalische Multiplikatoren und „Liability-Side Equivalence“ ab, aber sie beschäftigt sich auch mit dem aktuellen Thema der fiskalischen Abwertung.

Das erste Essay untersucht die Auswirkungen von Änderungen in der Mehrwertsteuer auf die gesamtwirtschaftliche Leistung einer Volkswirtschaft. Die Neuerung gegenüber bisherigen modellbasierten Publikationen über diese Fragestellung besteht in einer realistischen Modellierung des „tax pass-through“, also der Weitergabe von Steueränderung an Konsumenten durch Preisanpassungen. Die Untersuchung zeigt, dass eine empirisch plausible pass-through-Dynamik die kurzfristigen Mehrwertsteuer Multiplikatoren drastisch reduziert gegenüber denen in herkömmlichen Modellen. Die gewonnene Einsicht, dass Standard-Modelle der institutionellen und akademischen Forschung die kurzfristigen Multiplikatoren dramatisch überschätzen, kann potentiell zu einer Verbesserung von modellbasierten Politikempfehlungen beitragen.

Das zweite Essay befasst sich mit fiskalischen Abwertungen. Diese Politik zielt auf eine Abwertung des realen Wechselkurses – und damit auf eine Verbesserung der Wettbewerbsfähigkeit – ab, ohne dabei die Anpassung eines nominalen Wechselkurses zu erfordern. Sie sieht eine Senkung der Sozialabgaben vor, die durch eine Erhöhung der Mehrwertsteuer finanziert wird. Ein höherer Mehrwertsteuersatz macht importierte Güter teuer, während geminderte Sozialabgaben (und damit geminderte marginale Produktionskosten und Preise) inländische Güter im Ausland billiger machen. In dem Papier betrachten wir eine gemeinsame fiskalische Abwertung aller Peripherieländer der Eurozone. Die Neuerung gegenüber anderen Studien besteht darin, dass Lohnrigiditäten berücksichtigt werden – welche sich für die Effektivität der Reform als zentral erweisen –, und dass wir zwischen zwei Sorten von Abwertungen unterscheiden: Eine, in der Sozialabgaben der Arbeitgeber gesenkt werden, und eine, in der Sozialabgaben der Arbeitnehmer verringert werden. In unserem Modell ist die erstgenannte Form der Abwertung deutlich effektiver.

Das dritte Essay untersucht „Liability-Side Equivalence“ im Zusammenhang von Sozialabgaben. Dieses Prinzip besagt, dass die gesetzlich festgelegte Aufteilung der Abgaben zwischen Arbeitgebern und Arbeitnehmern langfristig keinerlei Konsequenzen für die reale Allokation hat. Ich zeige hingegen, dass die Aufteilung der Abgaben Auswirkungen auf makroökonomische Fluktuationen, auf die Effizienz der Allokation, und damit auf die langfristige Produktivität hat. Die einzige nicht in der Literatur übliche Annahme, die für dieses Ergebnis benötigt wird, ist, dass das Sozialsystem ein ausgeglichenes Budget hat.

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INTRODUCTION

During the 1930s, existing economic theory was unable to explain the causes of the Great Depression or to put forward an adequate policy response. John Maynard Keynes sparked a revolution in economic thinking that overturned the then-prevailing idea that full employment would automatically be achieved in a free market. Keynes did not see unbalanced government budgets as wrong, but advocated countercyclical fiscal policies to counteract business cycles. Deficit spending on infrastructure projects, for example, should be used to stabilize employment and stimulate output during economic downturns. However, activist fiscal policy for short-term economic stabilization was called into question in the 1960s, and the mainstream view was that fiscal policy should focus on structural concerns to foster long-run growth. After a long silence, the Great Recession led to a revival of interest in fiscal policy. It became apparent over the recent decade that monetary policy is unable to provide strong stimulus in a world of persistently low interest rates, so a thorough understanding of the means of fiscal policy to affect output is more relevant than ever. However, there is still no consensus in academic research on the dynamic impact of discretionary fiscal policy on macroeconomic aggregates. This thesis seeks to contribute to a better understanding of these dynamics.

The three chapters of this work have in common to analyze fiscal policy in theoretical frameworks that disaggregate government revenues into different types of distortionary taxes. They all address policy-relevant questions, for the most part related to the macroeconomic challenges of the European monetary union. In terms of methodology, all chapters employ New-Keynesian Dynamic Stochastic General Equilibrium Models of one or two interlinked economies. The thesis addresses classic macroeconomic topics like the fiscal multiplier and Liability-Side Equivalence – going back, respectively, to the early 20s and 30s of the previous century – as well the current subject of Fiscal Devaluations. The chapter on Fiscal Devaluations is co-authored and published in the IMF Economic Review, while the chapter on Liability-Side Equivalence was awarded the 2014 annual Best Paper Award of the German Research Foundation's Collaborative Research Center 649.

The first essay of this thesis, "Revisiting the effect of VAT changes on output: The importance of pass-through dynamics", is my job-market paper. In this work, I point out that standard models widely used in academic and institutional research – including workhorse models used at the ECB, the IMF and the European Commission – systematically overestimate the short-run impact of changes in the value-added tax (VAT) on output. The VAT is commonly implemented as a consumption tax levied on consumers, implying that tax changes instantaneously translate into consumer price changes, which corresponds to immediate tax pass-through. However, this is in conflict with a wealth of empirical evidence reporting that pass-through of VAT changes is only gradual. I investigate how the empirical implausibility of VAT pass-through in standard models can affect VAT multipliers. To this end, I employ a New-Keynesian DSGE model which features a standard consumption tax as well as a VAT. For the VAT, I develop a modeling strategy which reconciles tax pass-through in the model with empirical estimates. Comparing the impact of changes in the two taxes on output shows that short-run multipliers obtained for the consumption tax are roughly twice as large as those obtained for the VAT. The short-run impact of a VAT change is thus

dramatically weaker when the VAT is modeled such that it has an empirically plausible tax pass-through, than when it is modeled as a consumption tax and therefore has instantaneous tax pass-through. The reason is that intertemporal optimization leads agents to cut back spending when consumer prices rise, which happens instantaneously if the VAT is represented by a consumption tax, but only gradually if the tax hike transmits to consumer prices in line with empirical estimates. Standard models thus overestimate the short-run impact of VAT changes by neglecting to account for plausible VAT pass-through dynamics. Improving the accuracy of VAT multipliers obtained from theoretical models allows for more meaningful policy advice, especially because it can be crucial for the ordering of different fiscal instruments with regard to their suitability for some discretionary fiscal policy.

The second essay in this work is the co-authored paper “Fiscal Devaluation in a Monetary Union”. A Fiscal Devaluation is a revenue-neutral tax reform that increases the VAT and uses the additional tax revenues to lower social security contributions. It can improve a country’s competitiveness because increasing the destination-based VAT does *ceteris paribus* not affect the terms of trade, while lowering social security revenues means to reduce production costs, which is expected to decrease producer prices. Fiscal Devaluations are especially relevant in the context of monetary unions, it does not rely on the adjustment of a nominal exchange rate. In the paper, we show in a two-country DSGE model that Fiscal Devaluations are substantially more effective if the government reduces firms’ payroll taxes instead of labor income taxes. The intuition is that cutting payroll taxes directly lowers marginal costs and thereby prices, while a reduction in labor income taxes reduces marginal costs and prices only to the extent that it leads to lower wages. In a model with wage rigidity, this means that the deterioration in the terms of trade is delayed by an additional layer of nominal rigidity if labor income taxes are cut, while it is immediate when the government reduces payroll taxes.

The third essay “The statutory breakdown of payroll taxes between firms and workers and the business cycle” shows that the liability side of social security contributions (i.e. whether contributions are levied on firms or on workers) matters in a DSGE model for the long-run volatility of prices and wages. Since Liability-Side Equivalence holds in the model, the split of the economic incidence of the tax between firms and workers is independent of the liability side in the long run. As a result, nominal wages are higher if contributions are levied on workers – offsetting the tax burden – than if they are levied on firms. This means that total nominal labor compensation in the economy (the tax base of social security contributions) is larger under worker taxation as well. A higher steady state tax base implies that revenues react stronger to a given change in the tax rate. This matters because the contributions rate is assumed to adjust over the business cycle such that revenues are constant in the face of macroeconomic fluctuations. The higher responsiveness of revenues to tax rate changes under worker taxation allows to stabilize tax revenues with smaller changes in the contributions rate. A more stable contributions rate, in turn, leads to more stable prices and wages, implying a more efficient allocation and higher long-run productivity.

FIRST ESSAY

Revisiting the effect of VAT changes on output: The importance of pass-through dynamics

Standard models used in academic and institutional research implement the value-added tax (VAT) as a simple consumption tax levied on consumers, implying that tax changes instantaneously translate into consumer price changes. This corresponds to immediate tax pass-through, which is, however, inconsistent with a wealth of empirical evidence for gradual VAT pass-through. I investigate how empirically plausible pass-through dynamics affect VAT multipliers in a New-Keynesian DSGE model relative to instantaneous pass-through under the conventional modeling strategy. To this end, I propose an approach to reconcile VAT pass-through in the model with empirical estimates, and find that short-run multipliers decline by about 50% once we account for empirically observed pass-through dynamics. Standard models thus dramatically overestimate the short-run impact of VAT changes.

2.1 Introduction

The “New View” of fiscal policy (Furman, 2016) refers to the emerging consensus that discretionary fiscal policy is indispensable and can be effective in a world of persistently low interest rates. The renewed emphasis on fiscal policy is accompanied by a surge in academic interest (for surveys, see Ramey, 2011; Parker, 2011; Fatás & Mihov, 2009; Hebous, 2011; Leeper et al., 2015). For fiscal stimulus design and macroeconomic consolidation packages, it is crucial to have a precise understanding of the size of multipliers associated with different fiscal instruments. In the context of fiscal stimulus, the relative magnitudes of multipliers tell us which instrument provides the most “bang for the buck”; in the context of consolidation they tell us how a given improvement in the primary balance can be achieved with the smallest possible reduction in aggregate demand. Among fiscal instruments, the value-added tax (VAT) plays a prominent role: between 2007 and 2013, 15 EU countries increased the VAT in order to improve public finances (see Benedek et al., 2015). Japan plans to increase the VAT by 2% in 2019. This shows the central political relevance of VAT multipliers, especially in light of high levels of public debt in many developed countries. VAT reductions are also used to stimulate spending, as for example the 2.5% reduction in the UK in 2010. As of 2014, 160 countries employ a VAT, including all OECD member countries except the US.¹

The VAT is an indirect tax, so the tax liability accruing on sales of final products is not paid to the government by consumers themselves. Instead, the tax liability is a part of the retail price, so it is first paid to the respective seller (as e.g. a retail store or a service provider), who then pays it to the government on the buyer’s behalf.² A change in the tax liability thus only affects consumers when it passed on via the adjustment of retail prices – prior to price adjustments, a tax change only affects sellers, who now have to pay a larger or smaller VAT liability to the government. Rigidity in retail prices means that sellers do not immediately adjust prices to pass on a tax change to consumers, but only do so slowly. Hence the degree of pass-through of VAT changes is only partial in the short-run, or, put differently, pass-through occurs only gradually. Gradual pass-through dynamics are reported by a wealth of empirical evidence. For example, the comprehensive IMF study of Benedek et al. (2015) strongly rejects full contemporaneous pass-through in a sample of all VAT reforms in the Eurozone between 1999 and 2013: *“The null of full pass-through is firmly rejected, with the point estimates implying that only around one-third of a VAT change is passed forward to consumer prices”*. They conclude that *“[s]imply assuming full pass-through of all VAT reforms is, it seems, a significant mistake”*.

The conventional way of implementing the VAT in macroeconomic models is to use a simple ad valorem consumption tax that is directly paid to the government by consumers. I argue that this implicitly assumes instantaneous tax pass-through and is therefore inconsistent with the aforementioned empirical evidence. Consider the IMF’s workhorse DSGE model GIMF (Global Integrated Monetary and Fiscal model) as an example. The household’s tax liability per unit of consumption is given by $P_t^C \tau_{c,t}$, with P_t^C denoting the price index and $\tau_{c,t}$ the consumption tax rate (see Kumhof et al., 2010, p. 9). The tax liability moves proportionally with $\tau_{c,t}$, so if P_t^C was constant, a change in the tax liability would be fully paid by consumers. Sellers only pay a share of the tax change if there is a general equilibrium adjustment in P_t^C such that prices decline (increase) in the face of higher (lower) taxes. However, P_t^C is virtually constant in the short-run after a tax change, because standard models feature price and wage rigidity that delay general equilibrium price adjustments.³ Consumers thus effectively pay the change in

¹Source: OECD Consumption Tax Trends, 2014.

²VAT does not only accrue on sales of final goods and services, but also on upstream products. As discussed later on, this can be largely neglected in my analysis, which focuses on the macroeconomic implications of tax pass-through to final consumers.

³Anderson et al. (2013a) p.27 shows price adjustments in GIMF to a permanent fiscal consolidation in the size of 1% of GDP, implemented by higher consumption taxes. Prices decline by about 0.03% in the first year and by roughly 0.06% (0.08%) in the second (third) year after the tax hike started. Coenen et al. (2010) study the impact of fiscal stimulus in four different structural models. Without monetary accommodation, annual inflation in response to a two-year 1%-GDP decrease in consumption taxes is below 0.05% in the QUEST model, in the GIMF model, and in ECB’s NAWM model (p.106).

the consumption tax liability immediately when $\tau_{c,t}$ changes, and it is only in the medium term that P_t^C adjusts and firms participate in paying the tax change. However, for an indirect tax like the VAT, it is only under complete instantaneous pass-through that consumers immediately have to pay the full change in the tax liability. Implementing the VAT as a consumption tax paid by consumers thus implicitly assumes that instantaneous VAT pass-through is complete, which is strongly at odds with empirical evidence.

Despite this inconsistency, the conventional modeling strategy is adopted in both academic and institutional research.⁴ Examples of academic papers include Papageorgiou (2012), Coenen et al. (2013) and Coenen et al. (2012) on fiscal policy in Europe, Lipinska & Von Thadden (2012), Hohberger & Kraus (2016) and Engler et al. (forthcoming) on Fiscal Devaluations, and Eggertsson & Woodford (2004) on the liquidity trap in Japan. Regarding institutional research, the critique applies to a wealth of publications that apply the ECB's New Area-Wide and EAGLE models, the European Commission's QUEST model, the IMF's GIMF and FSGM models and the OECD's Fiscal model⁵ using the respective model's consumption tax to represent a VAT.⁶ This is especially relevant because leading policy-making institutions extensively draw on large-scale DSGE models to derive policy advice on the design of discretionary fiscal policy.

This paper investigates how empirically plausible pass-through affects the VAT multiplier relative to instantaneous pass-through under the conventional modeling approach. To this end I develop a New-Keynesian DSGE model which features an ad valorem consumption tax paid by households (representing the conventional implementation of the VAT) as well as a "realistic VAT" which is levied on the sellers of final goods and passed on to consumers in line with estimated VAT pass-through. We can replicate estimated pass-through because the tax liability of the realistic VAT is passed on via nominally rigid price markups, and the degree of rigidity (governing the speed of pass-through) is chosen accordingly. The model thus nests a VAT that is modeled in the conventional way (the consumption tax) and a VAT that features plausible tax pass-through (the realistic VAT). It is used to compare multipliers obtained under the two modeling strategies, which shows that short-run consumption tax multipliers are dramatically larger than those obtained for the realistic VAT. For example, increasing tax revenues by 1% of GDP for five years causes an average first-year GDP decline of 0.14% (0.06%) if it is achieved by increasing the consumption tax (realistic VAT). Gradual pass-through dampens the impact of tax changes because intertemporal optimization leads agents to cut back spending when consumer prices rise, which happens instantaneously if the VAT is represented by a consumption tax, but only gradually if the transmission of the tax hike to consumer prices is in line with empirical estimates. The results show that rigorous modeling of VAT pass-through dramatically reduces short-run multipliers relative to the conventional modeling strategy. Standard models thus overestimate the short-run impact of VAT changes, relative to a model that features empirically plausible VAT pass-through.

My contribution is to draw attention to the unsatisfactory implementation of the VAT in standard models (which is already mentioned, but not addressed, in Eggertsson, 2011) and to suggest a modeling strategy to reconcile VAT pass-through with empirical evidence. It allows us to improve the accuracy of VAT multipliers and to quantify the bias introduced by the conventional implementation. This is

⁴A consumption tax is suitable to represent the US-style sales tax, because pass-through of the sales tax is reported to be swift and comprehensive (see for example Poterba, 1996; Besley & Rosen, 1998). This is compatible with nominal rigidity because retail prices are quoted exclusive of the tax liability in the US.

⁵For model derivations, see Christoffel et al. (2008) for the New Area-Wide model, Gomes et al. (2010) for the EAGLE model, Ratto et al. (2009) for the QUEST model, Kumhof et al. (2010) for the GIMF model, Andrieu et al. (2015) for the FSGM model and Furceri & Mourougane (2010) for the OECD Fiscal model.

⁶For papers using GIMF, see IMF (2014b) (on Fiscal Devaluation in Spain), IMF (2014a) (on fiscal multipliers in Denmark), IMF (2013) (on fiscal consolidation in Hungary), Snudden & Klyuev (2011) (on fiscal consolidation in the Czech Republic), Anderson et al. (2013b) (on fiscal consolidation in various Euro Area countries) and IMF (2015) (on the impact of VAT hikes in Iceland). Arbatli et al. (2016) apply the recent FSGM model for Japan (that has a VAT). For ECB publications see Coenen et al. (2008) (monthly bulletin on fiscal consolidation), and Barrell et al. (2014) as well as ECB (2014) on multipliers. For the European Commission's QUEST model, see for example in't Veld (2013), Roeger & in't Veld (2010), and Giudice et al. (2003). Furceri & Mourougane (2010) applies OECD Fiscal to analyze the effects of fiscal policy in the euro area.

2.2. INSTITUTIONAL BACKGROUND AND EVIDENCE ON TAX PASS-THROUGH

especially relevant in the context of institutional research because the results suggest that a substantial body of policy advice suffers from overestimation of short-run VAT multipliers. Improving the accuracy of VAT multipliers can make this policy advice more meaningful, especially because it can be crucial for the ordering of different fiscal instruments with regard to their suitability for a given policy objective.

Section 2.2 of this paper summarizes empirical evidence on VAT pass-through and Section 2.3 presents the model and its calibration. Section 2.4 provides economic intuition for the results presented in Section 2.5. Section 2.6 discusses policy implications and Section 2.7 provides a robustness analysis. The paper concludes with Section 2.8.

2.2 Institutional background and evidence on tax pass-through

The European-style VAT taxes the value added at each stage of the supply chain (see, for example, the textbook Wendler et al., 2008). Each seller on the chain charges the VAT to the buyer and pays it to the government. At the same time, all buyers other than the end consumer are entitled to refund the VAT liability that accrued for the purchase of intermediate goods used in the production (final goods in the case of retailers). The tax liability for each business on the supply chain is thus a fraction of the difference between its revenues and its expenses for upstream products. Since the end consumer is charged the VAT for the final product but is not entitled for a refund, she or he ends up paying the total VAT liability.⁷ For the US-style sales tax, it also holds that ultimately only the end consumer is taxed. However, its collection procedure is simpler. Here, only the business that sells the final product to the end consumer charges the sales tax and pays it to the government.

Empirical evidence on VAT pass-through can be divided into studies that focus on a narrow set of goods and studies that investigate the impact of VAT changes on the CPI. Beginning with the former, Kosonen (2013) reports that a decline in the VAT on hairdressing services in Finland led to price reductions of only half of what full pass-through would imply. Carbonnier (2007) examines a reduction of the VAT on car sales and on housing repair services in France. In both cases, the pass-through was swift (during the first four months) but incomplete. For housing repair services, the consumer share of the tax reduction was estimated to be 77% and 57% for car sales. Politi & Mattos (2011) investigate VAT pass-through for ten different food items in Brazil. In their baseline specification, full pass-through is rejected for all items, with point estimates ranging from 55% for rice to 26% for bread. Regarding the second type of studies, the IMF publication Carare & Danninger (2008) looks at the 3% VAT hike in Germany in 2007. They report a cumulative pass-through of 73% over a time period of two years: one third occurred in the year preceding the reform due to anticipation effects, and the remaining two thirds took place in the implementation year. Various papers study the 13-month VAT reduction starting in December 2008 in the UK. Pike et al. (2009) estimate a pass-through of only a half, while Chirakijja et al. (2009) report substantial and rapid pass-through, with a point estimate of 75%. The Bank of England assumes that around half of the tax cut is passed on to consumers in the course of the 13-month reduction (Bank of England Inflation Reports for February 2009 (p.31) and for August 2010 (p.32)).

The most comprehensive study on VAT pass-through in Europe is the IMF study Benedek et al. (2015). The authors use a dataset that ranges from 1999 to 2013 and covers monthly price and tax data for 67 consumption items and 1231 VAT changes in total. To identify the impact of a VAT change on the consumer price of a commodity, the study uses as control variables the prices of the same commodity sold in countries other than the one in which the tax change occurred. Benedek et al. (2015) strongly reject full contemporaneous pass-through for the average VAT change. Because of the high statistical power of the dataset and its unmatched completeness, this study serves as the calibration target for baseline VAT pass-through in the model. It is discussed in more detail in the context of the calibration in Section 2.3.8.

⁷This paragraph concerns the statutory incidence and takes a long-run perspective in which all prices have adjusted such that every firm passes on its tax liability to the respective buyer.

2.3 Model

I model a small open economy that belongs to a monetary union and represents a country of Europe's distressed periphery, in which fiscal consolidation is highly relevant. The home country trades with the rest of the union (henceforth "RoU"), but RoU-countries are not affected by developments in the home country (apart from adjusting imports according to the terms of trade). Domestic households trade non-contingent bonds with RoU-households. In the baseline model, the home country has a negligible weight in the union-wide inflation measure stabilized by the central bank. Intermediate good prices and wages can only be adjusted in a staggered fashion. A government levies taxes and has constant government consumption defined as plain waste. The only non-standard component of the model is a retail firm sector which distributes the final good to households.

As mentioned before, the model nests the conventional VAT modeling strategy and a rigorous strategy that reconciles pass-through with empirical evidence. This is why the model features two taxes, an ad valorem consumption tax levied on households (the same tax that represents the VAT in standard models) and a "realistic VAT" which is levied on retail firms⁸ and passed on to consumers in a speed that corresponds to estimated VAT pass-through. To select one of the two alternative modeling strategies, one tax is set to zero, so the respective other tax generates all tax revenues. In particular, if the realistic VAT is set to zero, there is only the consumption tax, which is equivalent to a VAT modeled in the conventional way. Vice versa, setting the consumption tax to zero means that all revenues are generated by the realistic VAT, so we obtain the rigorous VAT modeling strategy featuring realistic pass-through dynamics. Later on we compare tax multipliers across these two model versions. This allows us to study how empirically observed pass-through dynamics affect the multiplier relative to instantaneous pass-through under the conventional modeling strategy.⁹ Since tax revenues are the same in both model versions and the two taxes only differ with regard to the speed of tax pass-through (the long-run tax incidence is thus the same), the steady state is identical across both model versions. Differences in multipliers are therefore only driven by different tax pass-through dynamics.

The set of model features is chosen to replicate the basic structure of the standard models mentioned in the introduction.¹⁰ The results derived from my model can thus be expected to carry over to standard models – that is, since short-run multipliers are dramatically smaller under plausible VAT pass-through in my model, the same can be expected for other models frequently used to analyze discretionary fiscal policy.

2.3.1 Households

Households on the continuum $[0, 1]$ are indexed by j . The index is neglected for the most part to ease notation. A household's lifetime utility is given by

$$U_t = \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \left(\frac{c_{t+k}^{1-\gamma}}{1-\gamma} - \frac{n_{t+k}^{1+\phi}}{1+\phi} \right), \quad (2.1)$$

where n_{t+k} and c_{t+k} are hours worked and consumption in period $t+k$.

⁸This shortcut is discussed in Section 2.3.2.

⁹Strictly speaking the consumption tax is not passed on, as it is levied on consumers. However, as discussed in the introduction, interpreting the consumption tax as VAT implicitly assumes instantaneous tax pass-through.

¹⁰It is therefore not surprising that consumption tax multipliers are broadly in line with those obtained from standard models. As shown in Section 2.5, the first-year consumption tax multiplier is 0.15%. In contrast, Coenen et al. (2010) report that the GIMF, QUEST and NAWM models generate multipliers in the range of 0.25%-0.33% for the euro area as a whole. Natural explanations for a smaller multiplier in my model are that it represents an individual country and thus has a trade share roughly twice as large as in Coenen et al. (2010), and that it does not feature rule-of-thumb consumers (the latter are introduced as a robustness exercise and raise the multiplier to 0.20%).

The household faces the following series of period budget constraints for $t \geq 0$:

$$(1 + \tau_t^c)P_t c_t + a_t + b_t \leq (R_{t-1} - RP_{t-1})a_{t-1} + (R_{t-1} - RP_{t-1})b_{t-1} + w_t(j)N_t(j) + \Pi_t - T_t, \quad (2.2)$$

where P_t denotes the retail price index, and c_t is the final consumption bundle, both introduced below. τ_t^c is the consumption tax rate, which allows us to replicate the conventional VAT implementation. $R_t - RP_t$ is the gross nominal interest rate (including a risk premium introduced below), and a_t as well as b_t are one-period risk-free nominal bonds. a_t is issued by the domestic government, and b_t denotes bonds traded with RoU-households. Both bonds mature at the beginning of period $t + 1$. $w_t(j)N_t(j)$ is nominal labor income, corresponding to the product of the household-specific wage $w_t(j)$ and its total employment at all intermediate good firms $i \in [0, 1]$, defined as $N_t(j) = \int_0^1 n_t(i, j) di$. T_t are lump-sum taxes, and Π_t denotes nominal profits from the ownership of firms (discussed in Section 2.3.2). Intertemporal optimization implies the following Euler equation:

$$R_t - RP_t = \beta \mathbb{E}_t \left(\frac{c_t}{c_{t+1}} \right)^\gamma \frac{P_t}{P_{t+1}} \frac{1 + \tau_t^c}{1 + \tau_{t+1}^c}. \quad (2.3)$$

$RP_t = -\phi^B B_t$ is a risk premium proposed by Schmitt-Grohé & Uribe (2003), with $B_t = \int_0^1 b_t(j) dj$ denoting aggregate bond holdings. It forces external debt to return asymptotically to its steady state level of zero after a shock, which is required for stationarity. However, ϕ^B is so small that the risk premium can be neglected in the short and medium term shock adjustment, and thus does not affect the results of this paper.

Hours worked are determined by labor demand. As discussed below, workers reduce their labor supply below the competitive level because they have market power.

The final consumption bundle c_t consists of retail good varieties from all retail firms on the continuum (indexed by $r \in [0, 1]$ and introduced in Section 2.3.2). Varieties of different retail firms $c_t^{ret}(r)$ are imperfect substitutes for households and are bundled with the following Dixit-Stiglitz aggregator:

$$c_t = \left[\int_0^1 \left(c_t^{ret}(r) \right)^{\frac{\epsilon_r}{\epsilon_r - 1}} dr \right]^{\frac{\epsilon_r - 1}{\epsilon_r}}. \quad (2.4)$$

Cost minimization implies a standard demand schedule for retail firm varieties:

$$c_t^{ret}(r) = \left(\frac{p_t^{ret}(r)}{P_t} \right)^{-\epsilon_r} c_t, \quad (2.5)$$

where $p_t^{ret}(r)$ is the price of retail variety r and P_t the retail price index, given by

$$P_t = \left(\int_0^1 \left(p_t^{ret}(r) \right)^{1 - \epsilon_r} dr \right)^{\frac{1}{1 - \epsilon_r}}. \quad (2.6)$$

2.3.2 Supply side

Intermediate good firms produce differentiated intermediate good varieties, which are sold domestically and exported to the RoU. A competitive final good firm bundles domestic intermediate goods as well as imports into a final good. In contrast to the standard model, the final good is not sold to households directly, but distributed by retail firms. These firms have market power, pay the realistic VAT (unless the tax rate is zero under the conventional modeling strategy) and charge price markups. As discussed in Section 2.3.2, rigidity in these markups is a shortcut to introduce gradual tax pass-through. Figure 2.1 summarizes the supply side (neglecting government consumption). Arrows denote the flow of goods and the respective price levels.

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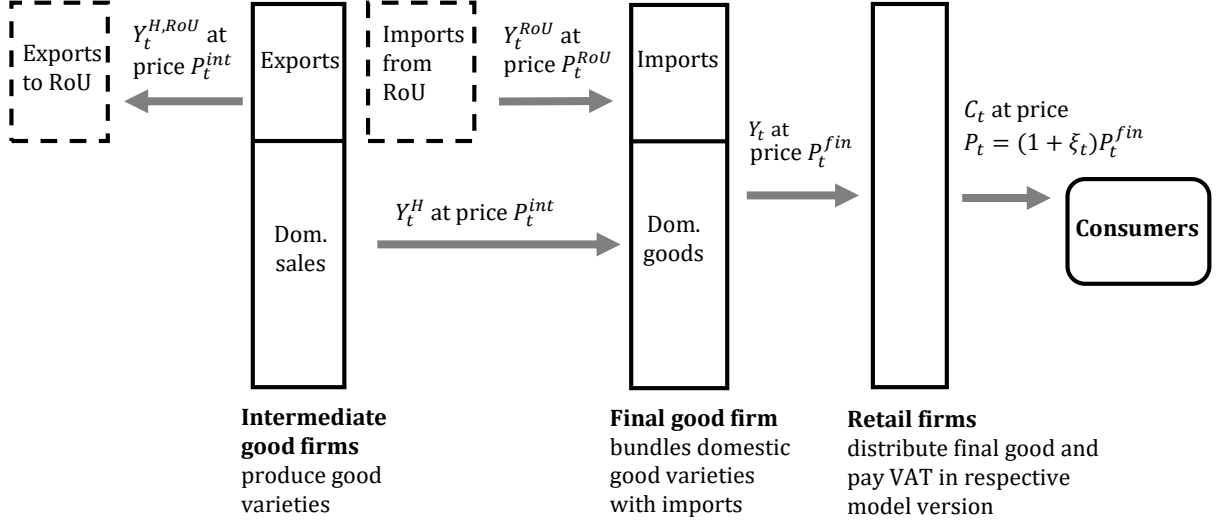


Figure 2.1: Supply side of the model economy.

Intermediate good producers

Intermediate good firm $i \in [0, 1]$ produces its variety $y_t(i)$ with a linear production function

$$y_t(i) = n_t(i) \quad . \quad (2.7)$$

The input is a composite $n_t(i)$ that contains differentiated labor services $n_t(i, j)$ of all households $j \in [0, 1]$:

$$n_t(i) \equiv \left(\int_0^1 n_t(i, j)^{1-\frac{1}{\epsilon_w}} dj \right)^{\frac{\epsilon_w}{\epsilon_w-1}} \quad . \quad (2.8)$$

Cost-minimizing composition of $n_t(i)$ implies the following demand schedule for type- j labor:

$$n_t(i, j) = \left(\frac{w_t(j)}{W_t} \right)^{-\epsilon_w} n_t(i) \quad , \quad (2.9)$$

where $w_t(j)$ is the wage for type- j labor and W_t is the aggregate wage index:

$$W_t \equiv \left(\int_0^1 w_t(j)^{1-\epsilon_w} dj \right)^{\frac{1}{1-\epsilon_w}} \quad . \quad (2.10)$$

Using (2.9) and (2.10), firm i 's total wage bill can be expressed as

$$\int_0^1 w_t(j) n_t(i, j) dj = W_t n_t(i) \quad . \quad (2.11)$$

Demand for firm i 's variety stems from domestic and foreign private consumption (the latter via exports) and from domestic government consumption. Defining total demand as Y_t^{total} (see Section 2.3.5 below) and using the fact that varieties are always bundled by technology (2.17), the demand schedule can be written as

$$y_t(i) = \left(\frac{p_t^{int}(i)}{P_t^{int}} \right)^{-\epsilon} Y_t^{total} \quad , \quad (2.12)$$

where $p_t^{int}(i)$ is the price of firm i 's variety and P_t^{int} the price index for intermediate goods, defined by

$$P_t^{int} \equiv \left(\int_0^1 p_t^{int}(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}. \quad (2.13)$$

Only a random share $(1 - \theta)$ of firms is allowed to re-adjust prices in a given period. A firm that is allowed to re-adjust its price solves the following problem:

$$\max_{p_t^{int}(i)} \mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k} \theta^k \left[y_{t+k|t}(i) p_t^{int}(i) - \Psi_{t+k}(y_{t+k|t}(i)) \right], \quad (2.14)$$

where $y_{t+k|t}(i)$ is period $t + k$ output (determined by (2.12)), given that the price set in t remains valid up to period $t + k$. The stochastic discount factor (SDF) is $Q_{t,t+k} \equiv \beta^k (c_{t+k}/c_t)^{-\gamma} (P_t(1 + \tau_t^c)/P_{t+k}(1 + \tau_{t+k}^c))$. The cost function $\Psi_t(\cdot)$ represents the firm's total wage bill (2.11), which, using (2.7), can be written as:

$$\Psi_{t+k}(y_{t+k|t}(i)) = W_{t+k} y_{t+k|t}(i). \quad (2.15)$$

The optimal price $(p_t^{int})^*$ set by re-adjusting firms is governed by the following FOC:

$$\mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k} \theta^k y_{t+k|t} \left[(p_t^{int})^* - \frac{\epsilon}{(\epsilon - 1)} W_{t+k} \right] = 0. \quad (2.16)$$

$(p_t^{int})^*$ is a markup over a weighted average of expected effective marginal costs, which are equal to the wage rate. Profits made by intermediate good firms are discussed in Section 2.3.2.

As explained below, rigidity in price markups charged by retail firms introduces gradual VAT pass-through in this model. Alternatively, gradual pass-through could in principle also be modeled by levying the realistic VAT on intermediate good firms. In this case, the FOC would imply that after-tax revenues (price divided by tax factor) are a markup over marginal costs, and a change in the tax liability would affect firm profits until prices can be adjusted in order to pass it on to consumers. This strategy, however, can only be adopted in a model that features a second pricing equation for the foreign market (i.e. a pricing-to-the-market strategy). Absent a second pricing equation, foreign prices would be adjusted in response to a change in the domestic VAT, which is inconsistent with the destination-based nature of the VAT: the VAT is reimbursed on exports, so it is not reasonable to assume that foreign prices are adjusted to pass on a change in the domestic VAT.

Final good producer

In a first step, the competitive final good firm bundles domestic intermediate goods into the domestic goods bundle Y_t^H , using technology

$$Y_t^H \equiv \left(\int_0^1 y_t(i)^{1-\frac{1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}. \quad (2.17)$$

In a second step, it bundles Y_t^H with the foreign goods bundle Y_t^{RoU} into the final consumption good Y_t . The aggregation technology is given by

$$Y_t = \left((1 - \omega)^{\frac{1}{\sigma}} (Y_t^H)^{\frac{\sigma-1}{\sigma}} + \omega^{\frac{1}{\sigma}} (Y_t^{RoU})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{1-\sigma}}, \quad (2.18)$$

where ω reflects home bias in consumption, and σ determines the elasticity of substitution between domestic goods and goods from the RoU.

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The price of the final good P_t^{fin} is given by:

$$P_t^{fin} = \left((1 - \omega) (P_t^{int})^{1-\sigma} + \omega (P_t^{RoU})^{1-\sigma} \right)^{\frac{1}{1-\sigma}}, \quad (2.19)$$

where P_t^{RoU} is the price index for the foreign goods bundle.¹¹ Cost-efficient bundling of Y_t implies the following demand schedule for the domestic intermediate goods bundle:¹²

$$Y_t^H = (1 - \omega) \left(\frac{P_t^{int}}{P_t^{fin}} \right)^{-\sigma} Y_t. \quad (2.20)$$

Since the terms of trade are one in the steady state of the model, the steady state import share is given by ω .

Retailers

The retail firm sector is the only non-standard model component and its purpose is to generate empirically plausible, gradual pass-through of the realistic VAT (model pass-through is illustrated in Section 2.3.8). It is loosely related to Monacelli (2005) on gradual exchange rate pass-through.

A retail firm $r \in [0, 1]$ buys the final good at price P_t^{fin} and sells it to households with a firm-specific markup $\xi_t(r)$, so its price $p_t^{ret}(r)$ is given by

$$p_t^{ret}(r) = (1 + \xi_t(r)) P_t^{fin}. \quad (2.21)$$

Retailers pay the tax-inclusive rate τ_t^v of the realistic VAT ($\tau_t^v = 0$ under the conventional modeling approach), so after-tax revenues per unit are given by $p_t^{ret}(r)/(1 + \tau_t^v)$.¹³

To derive a retail price index, substitute (2.21) into (2.6) and define

$$(1 + \xi_t) \equiv \left(\int_0^1 (1 + \xi_t(r))^{1-\epsilon_r} dr \right)^{\frac{1}{1-\epsilon_r}} \quad (2.22)$$

as the aggregate markup factor. The retail price index can then be written as

$$P_t = (1 + \xi_t) P_t^{fin}. \quad (2.23)$$

Retailers choose markups as to maximize the present value of expected profits subject to a Calvo constraint: in each period, a retailer is only allowed to re-adjust $\xi_t(r)$ with probability $0 < 1 - \theta^r < 1$. When deciding on $\xi_t(r)$, re-adjusting retailers solve the following problem:

$$\max_{\xi_t} \mathbb{E}_t \sum_{k=0}^{\infty} (\theta^r)^k Q_{t,t+k} y_{t+k|t}^{ret} \left[\frac{P_{t+k|t}^{ret}}{1 + \tau_{t+k}^v} - P_{t+k}^{fin} \right]. \quad (2.24)$$

Future profits are discounted by $Q_{t,t+k}$ because retail firms are owned by households.¹⁴ $y_{t+k|t}^{ret}$ is period $t + k$ demand for retailers that have not adjusted their markup since t and therefore still charge the price

¹¹Foreign prices are constant and assumed to equal domestic prices in the steady state.

¹²Demand for the foreign goods bundle is not shown because it has no relevance in a small open economy model.

¹³For a tax-inclusive rate, the tax liability is included in the tax base. The reason to define the consumption tax rate as tax-exclusive and the realistic VAT rate as tax-inclusive is that the former is standard in the models mentioned in the introduction, while the latter is standard in the empirical literature on VAT pass-through and simplifies the algebra. However, since the two tax rates are chosen such that revenues are identical across the two nested modeling strategies, this notational difference is irrelevant for the model allocation.

¹⁴Section 2.5 also considers different discount factors of retail firms (β^r), in which case the SDF reads as $Q_{t,t+k} \equiv (\beta^r)^k (c_{t+k}/c_t)^{-\gamma} (P_t (1 + \tau_t^c) / P_{t+k} (1 + \tau_{t+k}^c))$. This allows to study a broader set of pass-through dynamics, but comes at the cost of the inconsistency that retail firms use a different discount factor than their owners. However, apart from affecting pass-through dynamics, this has no further implications for the model's adjustment properties.

$p_{t+k|t}^{ret} = (1 + \xi_{t+k|t})P_{t+k}^{fin}$. It is determined by demand schedule (2.5). The square bracket subtracts expenses for buying one unit of the final good P_{t+k}^{fin} from the revenues from selling it on to consumers $p_{t+k|t}^{ret}/(1 + \tau_{t+k}^v)$, and thus denotes period $t + k$ after-tax profits.

Using (2.21) and (2.23) in (2.5), $y_{t+k|t}^{ret}$ can be written as $y_{t+k|t}^{ret} = \left(\frac{1 + \xi_{t+k|t}}{1 + \xi_{t+k}}\right)^{-\epsilon_r} C_{t+k}$, where $C_t \equiv \int_0^1 c_t(j) dj$ denotes aggregate consumption. Substituting $y_{t+k|t}^{ret}$ in (2.24) leads to the following FOC for newly set markups ξ_t^* :

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\theta^r)^k Q_{t,t+k} C_{t+k} P_{t+k}^{fin} (1 + \xi_{t+k})^{\epsilon_r} \left[\frac{1 + \xi_t^*}{1 + \tau_{t+k}^v} - \frac{\epsilon_r}{\epsilon_r - 1} \right] = 0 \quad . \quad (2.25)$$

Adjusting retailers choose $\xi_t(r)$ such that their price exceeds expenses for the final good (exploiting market power), and, for $\tau_t^v > 0$, also roll over the VAT liability to consumers. In the steady state, all firms have adjusted markups and charge ξ^* , so it holds that $(1 + \xi^*) = (1 + \xi) = \frac{\epsilon_r}{\epsilon_r - 1} (1 + \tau^v)$. If retail varieties were perfect substitutes ($\epsilon_r \rightarrow \infty$), the aggregate markup would equal the tax rate, so retailers would roll over the full tax liability and thus break even.¹⁵ However, since retailers have market power ($\frac{\epsilon_r}{\epsilon_r - 1} > 1$), they charge a higher price and therefore make profits in the steady state. These profits deviate from their steady state value in the short run when τ_t^v is shocked to compute multipliers under the rigorous VAT modeling strategy. A change in τ_t^v directly affects after-tax revenues, so if a retailer is not allowed to re-adjust its markup, the change in the tax liability fully falls on its profits. It is passed on to consumers only when the retailer is allowed to re-adjust. This means that the aggregate pass-through of a change in the tax liability depends on the share of retailers that adjusted markups in response. Since $\theta^r < 1$, the degree of the immediate aggregate pass-through is partial, and the value of θ^r determines the delay until full pass-through on the part of retail firms is achieved. It is the key parameter governing VAT pass-through dynamics and is chosen such that model pass-through is in line with empirical evidence.

The equilibrium allocation after a shock to τ_t^v under the conventional modeling strategy differs from the allocation after a revenue-equivalent shock to τ_t^v under the rigorous modeling strategy only in the short run when not all firms adjusted markups. Under the conventional strategy, the difference between consumer and producer prices immediately changes proportionally to $\Delta \tau_t^c$, while it also changed proportionally to $\Delta \tau_t^v$ under the rigorous strategy as soon as all retailers adjusted markups.¹⁶ Both model versions then imply the same allocation, because their only difference – the adjustment of consumer prices after a tax change – has disappeared.

As discussed in Section 2.3.2, an alternative way to model gradual pass-through is to levy VAT on intermediate good firms (provided that a model features country-specific pricing equations). Relative to this approach, my modeling strategy has the advantage that pass-through dynamics can be varied holding constant the model's general adjustment properties: changing θ^r affects VAT pass-through but not general inflation dynamics, while changing θ under the alternative modeling strategy would also alter the responsiveness of producer prices to marginal costs.

To determine the evolution of the aggregate markup factor ξ_t over time, note that a fraction $(1 - \theta^r)$ of re-adjusting retailers charge ξ_t^* , while the distribution of markups among non-adjusting retailers is the same as in the previous period. It follows that (2.22) can be written as

$$1 + \xi_t = \left(\int_{S(t)} (1 + \xi_{t-1}(r))^{1-\epsilon_r} dr + (1 - \theta^r) (1 + \xi_t^*)^{1-\epsilon_r} \right)^{\frac{1}{1-\epsilon_r}} \quad , \quad (2.26)$$

¹⁵ After-tax revenues per unit $\frac{p_t^{ret}(r)}{1 + \tau_t^v} = \frac{1 + \xi_t(r)}{1 + \tau_t^v} P_t^{fin}$ then equal P_t^{fin} , which are the expenses for one unit of the final good.

¹⁶ The portion of the retail markup that is due to market power is charged independently of retailers' taxes and thus also exists under the conventional modeling strategy ($(1 + \xi_t) = \frac{\epsilon_r}{\epsilon_r - 1} (1 + 0) \forall t$ for $\tau_t^v = 0$). Tax-inclusive consumer prices under the conventional strategy are thus given by $(1 + \tau_t^c) \frac{\epsilon_r}{\epsilon_r - 1} P_t^{fin}$, while they are given by $\frac{\epsilon_r}{\epsilon_r - 1} (1 + \xi_t) P_t^{fin}$ under the rigorous modeling strategy. When all retailers adjusted markups, ξ_t has changed by $\Delta \tau_t^v$, so the factor multiplying the final good price P_t^{fin} under the rigorous modeling strategy is then the same as under the conventional modeling strategy ($\Delta \tau_t^c = \Delta \tau_t^v$ for revenue-equivalent tax changes).

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where $S(t)$ denotes the set of non-adjusting retailers (which has a mass of θ^r). Using (2.22) for $t - 1$, the equation can be written as

$$1 + \xi_t = \left(\theta^r (1 + \xi_{t-1})^{1-\epsilon_r} + (1 - \theta^r) (1 + \xi_t^*)^{1-\epsilon_r} \right)^{\frac{1}{1-\epsilon_r}}. \quad (2.27)$$

Discussion of the modeling strategy

In reality, the VAT is levied on all firms on the supply chain for the value they add in the production process (see Section 2.2). For the model this would mean that intermediate good firms charge the VAT to the final good firm, which charges the VAT to retail firms, which in turn charges the VAT to consumers (the final good firm and retail firms would receive tax refunds). My model, however, only accounts for taxation at the final link of the supply chain (retailers charging VAT to consumers), and thus abstracts from taxation at all other segments of the chain. As argued in the following, the model is nevertheless well suited to study VAT multipliers, because all channels by which VAT changes affect output either operate in the same way as under a realistic collection scheme or have a direct empirical counterpart and are calibrated accordingly.

First, for the consumption decision of households, only pass-through at the final link of the supply chain matters, because it is only then that tax changes affect consumer prices.¹⁷ Empirical estimates of VAT pass-through (see Section 2.2) are a direct empirical counterpart for tax pass-through to consumers in my model, as these studies measure the final transmission of VAT changes to consumer prices. Note that the fact that the VAT is in reality levied across the entire supply chain certainly has implications for the pass-through of VAT changes to consumers, but these implications are incorporated in the empirical estimates. Thus, by replicating those estimates in the model, I implicitly account for the consequences that real-world VAT collection across the entire supply chain has for tax pass-through, without explicitly modeling it.

Second, we consider profits and household income. Levying VAT exclusively on retail firms means that when the government e.g. increases VAT revenues by a given amount, these revenues – prior to price adjustments – lower only retail firm profits. Under the real-world VAT collection scheme, in contrast, the reduction in profits (mirroring the additional VAT revenues) would be distributed across all firms along the supply chain.¹⁸ However, since households own all firms (see Section 2.3.2), their income is the same regardless of whether the profit loss is concentrated on retailers or distributed across all types of firms.

Third, expenditure switching effects only depend on the adjustment of intermediate good prices, because the VAT is a destination-based tax and therefore does not matter for the terms of trade.¹⁹ This is accounted for in the model because the VAT plays no role for the quantity of imports relative to domestic goods (see Section 2.3.2 on the final good firm, which bundles foreign and domestic goods), and because VAT does not matter for export demand (see the foreign portion in the total demand equation (2.35)). The strength of expenditure switching effects thus only depends on the adjustment dynamics of intermediate good prices (governed by θ), which are calibrated based on standard micro-evidence.

¹⁷Intertemporal substitution is governed by Euler equation (2.3) and depends on the adjustment of the real interest rate. The real rate is affected by the pass-through of changes in the tax liability to retail prices P_t , but, since the price indexes of upstream products (P_t^{int} and P_t^{fin}) neither enter the Euler equation nor the Taylor Rule (2.36), the real rate would not be affected by pass-through of VAT changes to prices of upstream products.

¹⁸Prior to price adjustments, a change in VAT revenues would be split among intermediate good firms, the final good firm, and retailers. Price adjustments would then cause the tax liability to be passed on downwards the supply chain to the consumer.

¹⁹The domestic VAT applies on imports and on domestic goods, while a foreign VAT applies on exports to the respective country as well as on goods produced and sold in that country. A country's VAT thus applies regardless of a good's origin and does therefore not affect relative prices between imports and domestic goods.

Profits

Profits of retailers and intermediate good firms are pooled and paid out to households. Aggregate profits Π_t are given by

$$\Pi_t = P_t^{int} Y_t^{total} - W_t N_t + \left[\frac{(1 + \xi_t) P_t^{fin}}{1 + \tau_t^v} - P_t^{fin} \right] C_t \quad , \quad (2.28)$$

where N_t is aggregate employment defined as $N_t = \int_0^1 n_t(i) di$, and Y_t^{total} is given by (2.35) below. Subtracting the aggregate wage bill from aggregate revenues of intermediate good firms (the first two terms) yields total profits in that sector. The third term denotes profits in the retail sector: the square bracket represents average profits per unit sold (after-tax revenues minus expenses to buy one unit of the final good) and is multiplied by total consumption.

2.3.3 Unions and wage setting

Following Erceg et al. (2000), households exert market power on the labor market because differentiated labor services are imperfect substitutes in (2.8). Each household j is represented by its own labor union that sets the household-specific wage rate $w_t(j)$ subject to a Calvo constraint: each period only a random share $1 - \theta^w$ of unions is allowed to re-adjust.

Aggregating demand equation (2.9) over all intermediate good firms yields

$$\int_0^1 n_t(i, j) di = \int_0^1 \left(\frac{w_t(j)}{W_t} \right)^{-\epsilon_w} n_t(i) di \quad (2.29)$$

which, using the definition for total type- j labor $N_t(j)$ (see (2.8)) and the definition of aggregate employment, can be written as:

$$N_t(j) = \int_0^1 \left(\frac{w_t(j)}{W_t} \right)^{-\epsilon_w} N_t \quad . \quad (2.30)$$

A union maximizes the expected present value of the household it represents, which is governed by

$$\max_{w_t(j)} \mathbb{E}_t \left[\sum_{k=0}^{\infty} (\beta \theta^w)^k U(c_{t+k|t}(j), n_{t+k|t}(j)) \right] \quad , \quad (2.31)$$

where $c_{t+k|t}(j)$ and $n_{t+k|t}(j)$ are period $t+k$ consumption and hours, given that the newly set wage is still valid. Maximization is subject to demand schedule (2.30). The optimal wage w_t^* satisfies the following FOC that (jointly with (2.10)) governs the evolution of aggregate wages:

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\beta \theta^w)^k MU_{t+k|t} n_{t+k|t} \left[\frac{w_t^*}{(1 + \tau_t^c) P_{t+k}} - \frac{\epsilon_w}{\epsilon_w - 1} MRS_{t+k|t} \right] = 0 \quad , \quad (2.32)$$

where $n_{t+k|t} = (w_t^*/W_{t+k})^{-\epsilon_w} N_{t+k}$ is period $t+k$ total demand for type- j labor, provided that w_t^* is still valid. $MU_{t+k|t}$ and $MRS_{t+k|t}$ denote household j 's period $t+k$ marginal utility and marginal rate of substitution, also conditional on w_t^* . For w_t^* , it holds that after-tax real wages are a markup over an expected weighted average of marginal rates of substitution.

2.3.4 Government

Government consumption G is constant and defined as plain waste. It consists of domestic intermediate goods aggregated by the same technology as in (2.17). The government issues bonds to domestic households, and $A_t = \int_0^1 a_t(j) dj$ denotes aggregate bond holdings. The period budget (for all $t \geq 0$) reads

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as

$$P_t^{int}G + R_{t-1}A_{t-1} = A_t + T_t + \tau_t^c P_t C_t + \frac{\tau_t^v}{1 + \tau_t^v} P_t C_t, \quad (2.33)$$

where $P_t^{int}G$ are consumption expenditures (the government does not pay taxes and is not dependent on the retail sector). The last two terms on the RHS are revenues from the consumption tax and from the realistic VAT – one of which is zero, depending on the model version. The respective non-zero tax rate is calibrated such that revenues equal expenditures in the zero-debt steady state²⁰ and can be exogenously shocked to obtain tax multipliers.

Lump-sum taxes T_t are introduced as technical device to make A_t stationary. T_t depends positively on the government's indebtedness:

$$T_t = \phi^A A_t. \quad (2.34)$$

The responsiveness parameter is set to $\phi^A = 0.0125$, which is marginally larger than the (quarterly) steady state interest rate. Consequently, T_t only reacts very mildly to deviations of A_t from zero, but forces A_t to asymptotically revert to its steady state value of zero after a shock.²¹

The public sector is highly stylized²², but rich enough to obtain multipliers from a fiscal consolidation. In either model version, the respective tax rate is shocked such that revenues increase by 1% of steady state GDP. The induced surplus leads to an accumulation of government assets ($A_t < 0$), because G is constant and T_t is effectively constant in the short and medium term due to the small value of ϕ^A . The obtained multipliers would be the same for a debt-financed fiscal stimulus because the model is symmetric in its approximation around the steady state.

2.3.5 Aggregate demand

Demand for the domestic goods bundle stems from domestic consumption (Y_t^H in (2.20)), government consumption, and exports. Assuming market clearing for final goods ($Y_t = C_t$), it is governed by

$$Y_t^{total} = (1 - \omega) \left(\frac{P_t^{int}}{P_t^{fin}} \right)^{-\sigma} C_t + \omega^{RoU} \left(\frac{P_t^{int}}{P^{fin,RoU}} \right)^{-\sigma} C^{RoU} + G, \quad (2.35)$$

where the second term is export demand. The price of the foreign final good in the RoU ($P^{fin,RoU}$) as well as RoU consumption (C^{RoU}) are constant and equal to the steady state values of the respective variables in the home country. The home bias parameter in the RoU (ω^{RoU}) is the same as in the home country, which implies balanced trade in the steady state.

2.3.6 Monetary policy

Monetary policy targets zero union-wide average inflation. It is described by the following standard Taylor Rule:

$$R_t = \beta^{-1} \left[n(\pi_t - 1) + (1 - n)(\pi_t^{RoU} - 1) \right]^{\alpha_\pi}, \quad (2.36)$$

²⁰Allowing for steady state government debt would only affect the model's adjustment properties (and thereby the results) if it significantly affected the real allocation in the steady state. However, steady state interest payments to households would not affect the real allocation if they were financed by lump-sum taxes. If they were financed by distortionary taxes, they would mildly affect the steady state allocation, but not enough to significantly change the model's adjustment properties.

²¹If ϕ^A were equal to the steady state interest rate, T_t would balance interest payments (revenues) for a given deviation $A_t > 0$ ($A_t < 0$). A_t would thus have unit root. A marginally higher value of ϕ^A ensures that T_t increases by enough to also redeem a positive fraction of the principle in the case of $A_t > 0$. Vice versa, in the case of $A_t < 0$, T_t declines by enough to pay out a positive fraction of the principle as lump-sum transfer.

²²A more realistic public sector that also features labor taxes is considered as robustness exercise in Section 2.7. It does not significantly change the results.

where α^π governs the responsiveness of monetary policy and n is the weight of the home country in the monetary union. n is set to a negligibly small value in the baseline calibration, so the nominal rate is virtually constant. This corresponds to the current monetary policy environment in the Eurozone – policy rates can effectively not be lowered further and are not expected to increase in the face of an overall depressed economy. A robustness exercise in Section 2.7 considers “normal times” and calibrates n to match HICP country weights of highly indebted Eurozone countries. The domestic inflation measure $\pi_t = (1 + \tau_t^c) P_t / (1 + \tau_{t-1}^c) P_{t-1}$ accounts for tax-inclusive consumers prices. $\pi_t^{RoU} = 1 \forall t$ is inflation in the RoU.

2.3.7 Calibration

Table 2.1 shows the baseline calibration of the quarterly model. It largely follows Evers (2012) who calibrates a related model to members of the EMU. Calvo probabilities for prices and wages correspond to the empirical findings of Druant et al. (2009), who report for the Euro Area an average lifetime of prices and wages of 9.6 and 12.5 months respectively (excluding the outlier Italy). Elasticities of substitution between different good varieties and labor types match 11% price markup and 15% wage markup, as estimated in Basu & Kimball (1997) and Chari et al. (2002). The steady state import share is 0.33 as in Evers (2012).

Table 2.1: Baseline parameters

Parameter	Value	Motivation / target
β Discount factor	0.99	Annual risk-free rate of 4%
γ Relative risk aversion	1	Log-utility
ϕ^{-1} Frisch elasticity of labor supply	1	Kimball (2008)
ϵ Elasticity of substitution goods varieties	10	11% price markup, Basu (1997)
ϵ_w Elasticity of substitution types of labor	7.4	15% wage markup, Chari et al. 2002
θ Calvo probability firms	0.6875	Avg. lifetime 9.6 months, Druant et al. 2009
θ^w Calvo probability unions	0.76	Avg. lifetime 12.5 months, Druant et al. 2009
α^π Inflation coefficient in Taylor Rule	1.5	Standard
n Weight of home country in Taylor Rule	0.01	Small country assumption / passive monetary policy
ω Steady state import share	0.33	Evers (2012)
τ^v Steady state tax rate European VAT model	20% (0%)	Eurozone avg., Lipinska & Von Thadden (2012)
τ^c Steady state tax rate cons. tax model	21.3% (0%)	Same revenues as in European VAT model
G Government spending	0.165	Balanced budget in steady state
θ^r Calvo probability of retail firms	0.75	Avg. lifetime markup: 1 year
ϵ_r Substitution elasticity retail varieties	30	Retailers' profits 20% of total profits

The steady state tax rate under the rigorous modeling strategy τ^v is 20%, which Lipinska & Von Thadden (2012) report to be the Eurozone average. Under the conventional modeling strategy, the steady state tax rate τ^c is 21.3%, leading to the same revenues.²³ Government consumption $G = 0.165$ corresponds

²³ τ_t^v is defined as tax-inclusive rate, so the effective tax rate under the rigorous modeling strategy is $\tau_t^v / (1 + \tau_t^v) = 20\% / (1 + 20\%) = 16.67\%$, which is smaller than the effective rate of $\tau_t^c = 21.3\%$ under the conventional modeling strategy. Revenues are nevertheless the same, because a larger tax base under the rigorous modeling strategy compensates for the smaller effective tax rate. To see why, use (2.23) to rewrite the tax base $P_t C_t$ as $(1 + \xi_t) P_t^{fin} C_t$. While P_t^{fin} and C_t are the same in both model versions, ξ_t (and with it the tax base) is higher in the steady state under the rigorous modeling strategy because retail firms roll over the VAT liability.

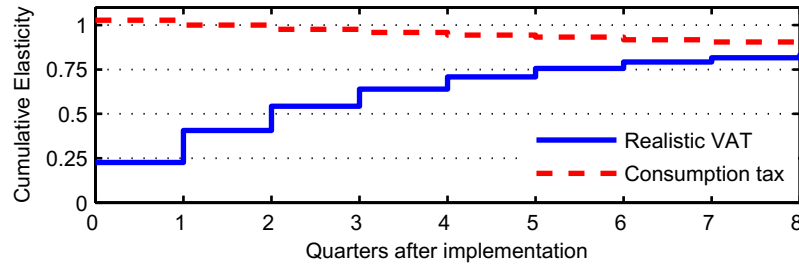


Figure 2.2: Cumulative pass-through under both modeling strategies.

to about 18% of steady state GDP and implies a balanced budget in the steady state. A robustness exercise also considers a larger government (45% of GDP) that also levies labor taxes. Substitution elasticity $\epsilon_r = 30$ implies that about one fifth of total profits accrue in the retail sector, which is in line with data for the US.²⁴ Retail markup rigidity θ^r is 0.75 in the baseline calibration, implying an average lifetime of a markup of one year. The resulting pass-through dynamics are illustrated in the following subsection.

2.3.8 Model pass-through

Figure 2.2 illustrates pass-through of an exogenous change in τ_t^v under the rigorous modeling strategy, as well as the impact on consumer prices of a change in τ_t^c under the conventional approach (i.e. the implicit pass-through when the VAT is implemented as a consumption tax). Analogous to Benedek et al. (2015), pass-through at a given time after a tax change is defined as the cumulative proportionate response of consumer prices divided by the proportionate change in the tax factor.²⁵ A value of one denotes complete pass-through. We consider a permanent tax increase raising annual revenues by 1% of steady state GDP.

Under the conventional modeling strategy, changes in τ_t^c directly enter consumer prices (see budget (2.2)). The degree of (implicit) pass-through is thus full on impact and subsides only slowly due to general equilibrium price adjustments, which are delayed by price and wage rigidity. This exercise illustrates that using a consumption tax to represent the VAT in a model with price and wage rigidity – as the workhorse DSGE models mentioned in the introduction – implies VAT pass-through dynamics that strongly contradict empirical evidence. Figure 2.3 is taken from Benedek et al. (2015) and shows VAT pass-through for their baseline estimation that includes all VAT changes in their sample. The point estimate for immediate tax pass-through (at $t=0$) is about 22%, as opposed to 100% model pass-through under the conventional modeling strategy.

Under the rigorous modeling strategy, changes in τ_t^v only affect consumer prices via adjustments in retail markups. Their baseline rigidity ($\theta^r = 0.75$) is calibrated such that immediate VAT pass-through corresponds to empirical evidence: Figure 2.2 shows that pass-through on impact is 25% in the model, while the empirical point estimate is 22%. In the short run after the tax change, model pass-through overshoots the point estimate and roughly corresponds to the upper end of the confidence interval. This is done for the sake of a conservative calibration: weaker pass-through (closer to the point estimate)

²⁴Using different values of ϵ_r is virtually irrelevant for the model's adjustment properties. The calibration data comes from the 2014 National Income and Product Accounts (NIPA) of the U.S. Bureau of Economic Analysis, which provides corporate profits by industry. Retail trade and wholesale trade (both sectors that distribute final goods) make about one fifth of total profits of non-financial firms.

²⁵Denoting steady state values without time subscript, cumulative pass-through after t periods is given by $\frac{P_t^{cpi} - P^{cpi}}{P^{cpi}} / \frac{\tau_t - \tau}{1 + \tau}$, where τ is the respective tax rate (either τ_t^c or τ_t^v), and $P_t^{cpi} = (1 + \tau_t^c)P_t = (1 + \tau_t^v)(1 + \xi_t)P_t^{fin}$ is in either model version the consumer price index.

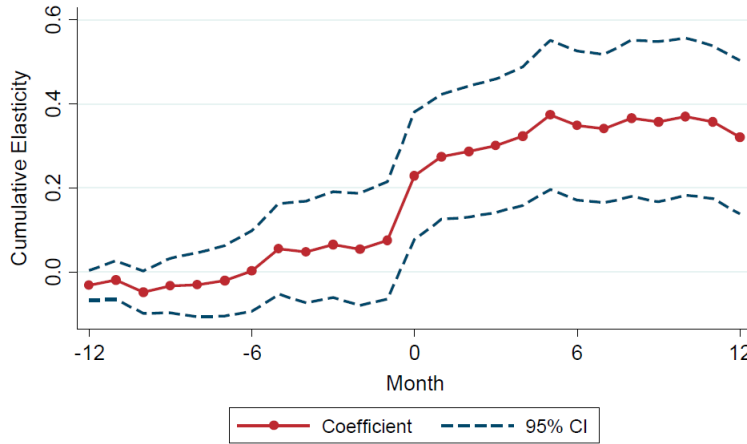


Figure 2.3: Estimated cumulative pass-through in the Eurozone. Source: Benedek et al. (2015).

strengthens the model's deviation from full instantaneous pass-through under the conventional modeling strategy. Later on, I present the results for a variety of different pass-through dynamics.

Figure 2.2 shows that in both model versions, the share of the additional tax liabilities that is paid by consumers converges to roughly 80% in the long run (determined by demand and supply elasticities). Differences between pass-through of the realistic VAT and implicit pass-through of the consumption tax are thus only significant for about two years after a tax change (as discussed in Section 2.3.2, pass-through is identical across both model versions when all retailers adjusted markups). This is desirable because sound evidence for partial pass-through – that justifies a departure from the conventional modeling strategy – exists only for the short run after a VAT change: the studies mentioned in Section 2.2 typically document pass-through during a time window ending one or two years after a VAT change, while no study explicitly addresses pass-through in the long run.

2.4 Dissecting multipliers

To build intuition for differences between multipliers of the realistic VAT and of the consumption tax, we consider an exemplary fiscal consolidation in each of the two model versions. The respective tax rate (τ_t^r or τ_t^v) increases exogenously such that quarterly tax revenues rise by 0.25% of steady state GDP for three years, and the government uses the additional revenues to buy assets.²⁶ Impulse response functions (as well as multipliers reported in subsequently sections) are obtained from perturbation in Dynare. Tax rates, interest rates and inflation rates are depicted in annualized units.

2.4.1 Conventional VAT modeling strategy

Figure 2.4 shows the fiscal consolidation when it is implemented by a higher consumption tax – which represents the impact of a VAT increase in standard models. Output exceeds private consumption (the tax base) by the amount of government spending, so a given percentage change in the tax rate leads to a smaller percentage change in tax revenues per GDP. This is why τ_t^c has to increase by about 1.4% to

²⁶As argued in Section 2.3.4, we would obtain the same multipliers for debt-financed tax cuts.

elevate revenues by 1% of steady state GDP (1,4)²⁷. The government lends additional revenues back to households, so the tax hike does *ceteris paribus* not affect households' available resources. As discussed below, households reduce consumption by about 0.22% of steady state GDP (1,1). This only lowers output by roughly 0.15%, because households also reduce imports (1,2) and because constant government consumption stabilizes demand. The overhang of the reduction in consumption expenditures over the reduction in income is lent to foreign households and leads to an accumulation of foreign bond holdings (1,3).

The nominal rate (not shown) is virtually constant due to the home country's small weight in the union. As in the reference models mentioned in the introduction, intermediate good prices are very stable (2,1), because wage rigidity prevents wages (3,3) and thereby marginal costs (3,2) from adjusting swiftly.²⁸ With stable producer prices, the real interest rate adjustment is dominated by changes in the consumption tax and therefore peaks in period 12 when the tax rate reverts to its initial level (2,2). This implies an increase in the long-term real rate (the forward-looking average of one-period real rates) already at the onset of the consolidation (2,2), and explains why consumption drops as soon as the tax increases (1,1). Intuitively, households anticipate that consumer prices will decline when the fiscal consolidation comes to an end and postpone consumption until then.

Stable intermediate goods prices also explain why the depreciation in the terms of trade (2,3) and the resulting expenditure switching (1,2) is negligible.

2.4.2 Rigorous VAT modeling strategy

Figure 2.5 shows the same fiscal consolidation as in the previous exercise, but under the rigorous VAT modeling strategy. To facilitate a comparison, dashed blue lines (with circles as markers) replicate the adjustment shown in Figure 2.4. As in the previous case, the tax rate (now τ_t^v) has to rise by about 1.4% to improve the primary balance by 1% of steady state GDP (1,4). We begin by examining the aggregate retail markup (3,4), which increases (as a rising number of retail firms roll over the additional tax liability to consumers) and peaks after eight quarters ($t=8$). Retailers lower their markups already before the tax hike ends in $t=12$ because they are forward-looking and anticipate the reversal of the tax hike when it comes near. However, the aggregate markup remains elevated for about two more years after the tax hike ends, as Calvo-rigidity only allows a gradual return to initial retail prices.

The real rate (2,2) mirrors CPI inflation (2,1) since the nominal rate is constant. CPI inflation, in turn, is predominantly driven by the adjustment of retail markups because intermediate good prices are again very stable in the short run (2,1). The real rate thus deviates negatively as long as the aggregate retail markup rises (until $t=8$), and positively when it reverts downward. This gives rise to the hump-shaped deviation of the long-term real rate (2,2) and explains the adjustment path of consumption (1,1). Output (1,1) declines by less than consumption for the same reasons as in the previous exercise.

In either of the two model versions, consumption declines because consumer prices rise. The key difference is that the consumption tax change has a direct and immediate impact on consumer prices, while the change in the realistic VAT immediately affects retailers' profits (2,4) and is only gradually passed on to consumer prices. As a consequence, the short-run consumption decline is dramatically weaker for the realistic VAT. A further difference is that the reversion of consumption to its initial level is gradual for the realistic VAT, while it is abrupt for the consumption tax.

²⁷ Parentheses indicate the relevant panel and read as (row, column).

²⁸ Flexible wages are examined in the robustness analysis. A further reason for the mild wage adjustment is that the MRS (3,1) declines in line with effective real wages (accounting for the consumption tax) (3,3). (Effective real wages decline for a given nominal wage due to the hike in the consumption tax, while the MRS drops because of lower consumption and hours.) As a result, no substantial adjustment of nominal wages is required in order to maintain the optimal proportion $\frac{\epsilon_w}{\epsilon_w - 1}$ between effective real wages and the MRS.

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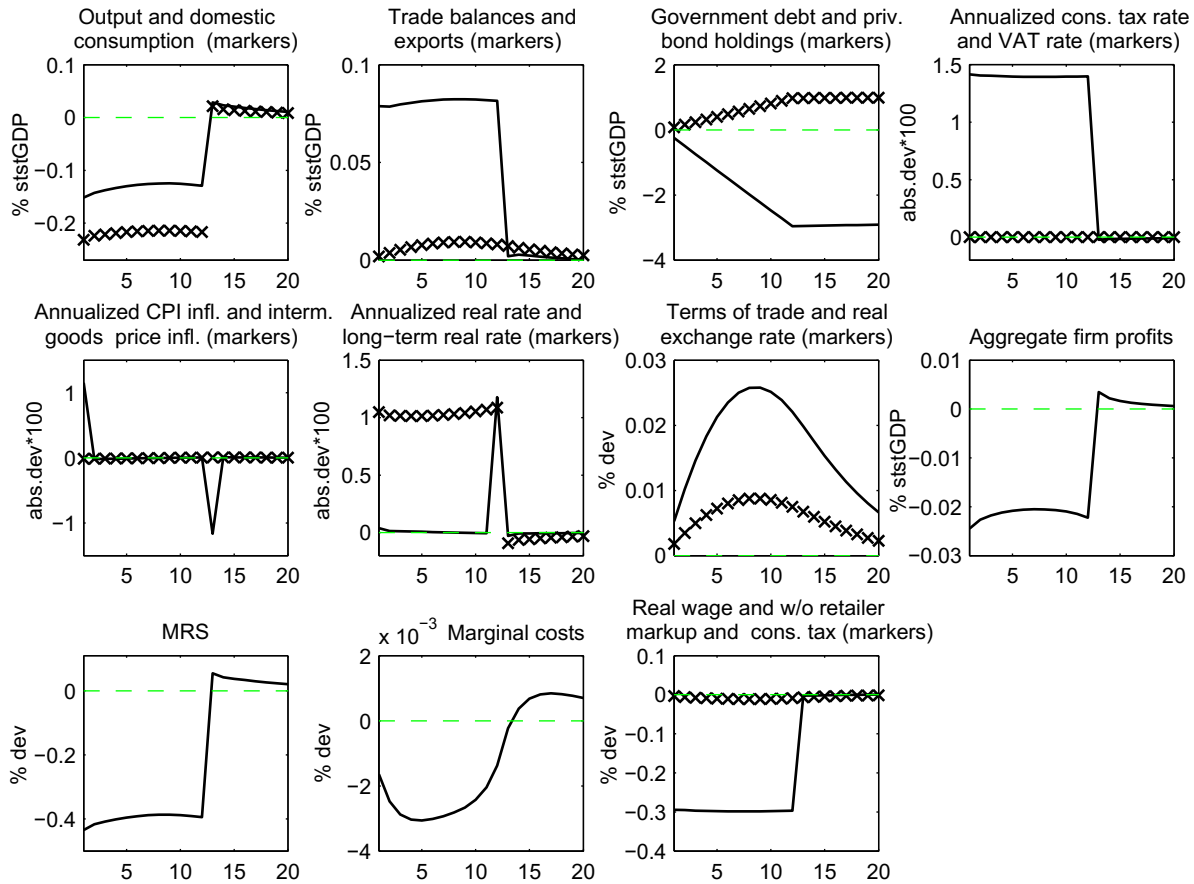


Figure 2.4: Three-year consolidation under the conventional VAT modeling strategy.

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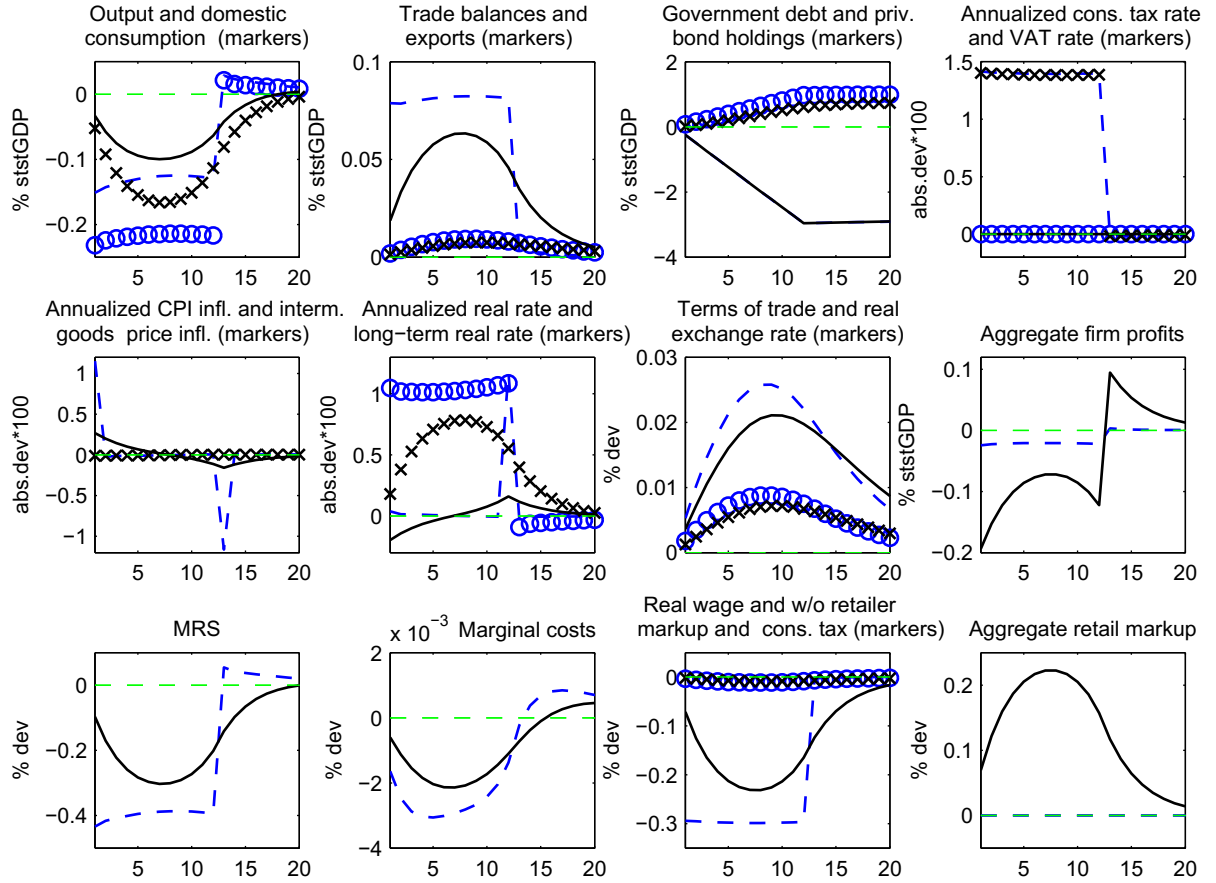


Figure 2.5: 3-year consolidation under the rigorous VAT modeling strategy.

2.5 Comparing multipliers

Table 2.2 compares multipliers in the two model versions, obtained from fiscal consolidations which improve the annual primary balance by 1% of steady state GDP for one, two, five and 20 years.²⁹ For each consolidation, the top row depicts consumption tax multipliers and the remaining rows depict realistic VAT multipliers for different calibrations of pass-through dynamics: we consider 0.67, 0.75 (baseline), and 0.85 for markup rigidity θ^r , and 0.85 as well as 0.99 (baseline) for retailers' discount factor β^r .³⁰ For each calibration, columns one to three show the resulting VAT pass-through on impact and after one and two years.³¹ The table depicts various multiplier statistics: the impact multiplier (percentage change of GDP when the consolidation begins), the peak multiplier (peak percentage deviation of GDP), as well as average multipliers for one, two, five, and 20 years (average percentage deviations of GDP). The last column also reports the average GDP adjustment in the time between the beginning of the respective consolidation and two years after its end.³² Parentheses next to realistic VAT multipliers indicate percentage-reductions that make them as large as their consumption tax counterparts.

Regardless of the consolidation duration and the calibration of realistic VAT pass-through, short-run multipliers (impact, one-year and two-year multipliers) are dramatically smaller for the realistic VAT. The explanation follows directly from the discussion in Section 2.4: delay in tax pass-through dampens the short-run GDP adjustment because it defers the incentive to postpone consumption. Now consider multipliers averaging over the entire time of a consolidation and the multiplier-like statistic for the overall impact of a consolidation (last column). These figures are also smaller for the realistic VAT, but differences are smaller for longer consolidations. For example, under the baseline calibration ($\theta^r = 0.75$, $\beta^r = 0.99$), the two-year realistic VAT multiplier for the two-year consolidation is only 52% of its consumption tax counterpart, while the difference for the 20-year multiplier and the 20-year consolidation is only 7%. The reason is that the impact of consumption tax changes and realistic VAT changes on consumer prices only differ in the short run, i.e. as long as pass-through on the part of retail firms is only partial (see Section 2.3.8). Thereafter, both tax changes affect consumers in the same way, which implies an identical allocation in both model versions. The time interval in which the allocation differs across both model versions has a smaller weight in multiplier statistics that average over a longer time horizon. For example, it covers the entire time span of a two-year average multiplier, but only a fraction of the time span accounted for by a twenty-year multiplier. Regarding the different calibrations of pass-through of the realistic VAT, we observe that time-discounting of retail firms β^r is of minor importance, while stronger rigidity in retail markups (a larger θ^r) increases the differences between consumption tax and realistic VAT multipliers. Stronger markup rigidity means that pass-through of realistic VAT changes takes longer, implying a larger delay in the consumption adjustment.

The overall picture is that differences between both VAT modeling strategies are striking for impact multipliers, one-year and two-year average multipliers, as well as for peak multipliers. By and large, incorporating realistic pass-through dynamics reduces the one-year (two-year) average GDP decline by roughly 50%-80% (30%-60%), relative to the projections in the model version that implements the VAT as a consumption tax paid by households. Even for the weakest calibration of retail markup rigidity $\theta^r = 0.67$, the first-year multiplier declines by at least 43%. $\theta^r = 0.67$ implies that, taking the 20-year consolidation as example, 74% of the tax change is passed on to consumers after one year. This pass-through speed is at the upper end of the estimates discussed in Section 2.2, so the 43% can be interpreted

²⁹The 20-year consolidation symbolizes a permanent VAT hike.

³⁰As discussed in Section 2.3.2, different time-discounting of retail firms and of intermediate good firms is not logically consistent, but it has no other implications than affecting VAT pass-through dynamics.

³¹As in Section 2.3.8, pass-through is defined as cumulative proportionate response of consumer prices to an increase in the VAT tax factor.

³²This is not a multiplier in the strict sense because the average includes time periods after a consolidation. By accounting for output deviations that persist for some quarters after the end of a consolidation, the statistic measures the consolidation's overall impact.

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Table 2.2: VAT multipliers under both VAT modeling strategies

	Cumulative PT			Impact	Peak	Average multipliers				Avg. adjustment
	impact	1 year	2 years	multiplier	multiplier	1 year	2 years	5 years	20 years	duration +2 yrs.
One-year consolidation										
Consumption tax	100%	98%	—	0.16	0.16	0.15	—	—	—	-0.05
$\theta^r = 0.67 \beta^r=0.85$	29%	49%	—	0.05 (-71%)	0.08 (-48%)	0.07 (-55%)	—	—	—	-0.03 (-32%)
— $\beta^r=0.99$	26%	41%	—	0.04 (-73%)	0.07 (-55%)	0.06 (-61%)	—	—	—	-0.03 (-41%)
$\theta^r = 0.75 \beta^r=0.85$	20%	38%	—	0.03 (-80%)	0.06 (-61%)	0.05 (-67%)	—	—	—	-0.03 (-42%)
— $\beta^r=0.99$	17%	29%	—	0.03 (-83%)	0.05 (-69%)	0.04 (-73%)	—	—	—	-0.02 (-54%)
$\theta^r = 0.85 \beta^r=0.85$	10%	22%	—	0.02 (-90%)	0.03 (-78%)	0.03 (-82%)	—	—	—	-0.02 (-60%)
— $\beta^r=0.99$	7%	14%	—	0.01 (-93%)	0.02 (-86%)	0.02 (-88%)	—	—	—	-0.01 (-74%)
Two-year consolidation										
Consumption tax	99%	95%	95%	0.15	0.15	0.15	0.14	—	—	-0.06
$\theta^r = 0.67 \beta^r=0.85$	31%	73%	60%	0.05 (-69%)	0.11 (-26%)	0.08 (-43%)	0.09 (-34%)	—	—	-0.05 (-18%)
— $\beta^r=0.99$	30%	69%	52%	0.05 (-70%)	0.11 (-31%)	0.08 (-45%)	0.09 (-38%)	—	—	-0.05 (-25%)
$\theta^r = 0.75 \beta^r=0.85$	23%	59%	54%	0.03 (-78%)	0.10 (-38%)	0.06 (-56%)	0.08 (-46%)	—	—	-0.05 (-26%)
— $\beta^r=0.99$	21%	53%	44%	0.03 (-79%)	0.08 (-46%)	0.06 (-59%)	0.07 (-52%)	—	—	-0.04 (-36%)
$\theta^r = 0.85 \beta^r=0.85$	13%	38%	41%	0.02 (-88%)	0.06 (-58%)	0.04 (-74%)	0.05 (-65%)	—	—	-0.04 (-43%)
— $\beta^r=0.99$	10%	29%	28%	0.02 (-90%)	0.05 (-70%)	0.03 (-79%)	0.04 (-74%)	—	—	-0.03 (-58%)
Five-year consolidation										
Consumption tax	99%	92%	87%	0.15	0.15	0.14	0.13	0.12	—	-0.08
$\theta^r = 0.67 \beta^r=0.85$	31%	72%	83%	0.04 (-71%)	0.11 (-26%)	0.08 (-44%)	0.09 (-27%)	0.10 (-15%)	—	-0.07 (-8%)
— $\beta^r=0.99$	31%	72%	83%	0.04 (-71%)	0.11 (-25%)	0.08 (-44%)	0.09 (-26%)	0.10 (-17%)	—	-0.07 (-11%)
$\theta^r = 0.75 \beta^r=0.85$	23%	61%	78%	0.03 (-80%)	0.10 (-29%)	0.06 (-56%)	0.08 (-38%)	0.09 (-22%)	—	-0.07 (-12%)
— $\beta^r=0.99$	23%	60%	77%	0.03 (-79%)	0.10 (-30%)	0.06 (-56%)	0.08 (-38%)	0.09 (-25%)	—	-0.06 (-17%)
$\theta^r = 0.85 \beta^r=0.85$	13%	41%	61%	0.02 (-89%)	0.09 (-38%)	0.04 (-73%)	0.05 (-57%)	0.07 (-37%)	—	-0.06 (-22%)
— $\beta^r=0.99$	13%	40%	58%	0.02 (-89%)	0.08 (-45%)	0.04 (-74%)	0.05 (-58%)	0.07 (-44%)	—	-0.05 (-32%)
20-year consolidation										
Consumption tax	99%	93%	88%	0.14	0.14	0.13	0.12	0.10	0.09	-0.08
$\theta^r = 0.67 \beta^r=0.85$	31%	74%	85%	0.03 (-77%)	0.10 (-25%)	0.07 (-47%)	0.08 (-28%)	0.09 (-11%)	0.09 (-3%)	-0.08 (-1%)
— $\beta^r=0.99$	32%	74%	85%	0.03 (-76%)	0.10 (-25%)	0.07 (-47%)	0.08 (-28%)	0.09 (-12%)	0.09 (-4%)	-0.08 (-2%)
$\theta^r = 0.75 \beta^r=0.85$	23%	63%	80%	0.02 (-86%)	0.10 (-29%)	0.05 (-60%)	0.07 (-40%)	0.08 (-17%)	0.09 (-6%)	-0.08 (-2%)
— $\beta^r=0.99$	23%	63%	80%	0.02 (-86%)	0.10 (-29%)	0.05 (-60%)	0.07 (-40%)	0.08 (-18%)	0.08 (-7%)	-0.08 (-4%)
$\theta^r = 0.85 \beta^r=0.85$	14%	44%	65%	0.01 (-96%)	0.09 (-33%)	0.03 (-78%)	0.05 (-60%)	0.07 (-31%)	0.08 (-10%)	-0.08 (-5%)
— $\beta^r=0.99$	14%	44%	64%	0.01 (-96%)	0.09 (-36%)	0.03 (-78%)	0.05 (-60%)	0.07 (-31%)	0.08 (-12%)	-0.07 (-8%)

as the lower bound of the difference in the first-year multipliers across the two VAT modeling strategies.

2.6 Policy implications

In the context of workhorse DSGE models used at policy-making institutions, the conventional VAT modeling strategy – and the associated overestimation of short-run multipliers – can significantly affect policy advice. As example, consider Coenen et al. (2008), who apply the ECB's New Area-Wide Model (NAWM) to analyze fiscal consolidation strategies that reduce the debt ratio in the Euro Area from 70% to 60%. Figure 2.6 is from their paper and compares the impact of increasing labor income and consumption taxes, with the latter representing the VAT.

In the first eight quarters following the tax hike, the consumption tax has a significantly stronger adverse impact on output than the labor income tax (right panel). This could weaken the case for the use of the VAT as fiscal instrument, especially for countries that are in severe recession. However, my paper suggests that the short-run impact of the VAT hike would be significantly weaker if the VAT was not

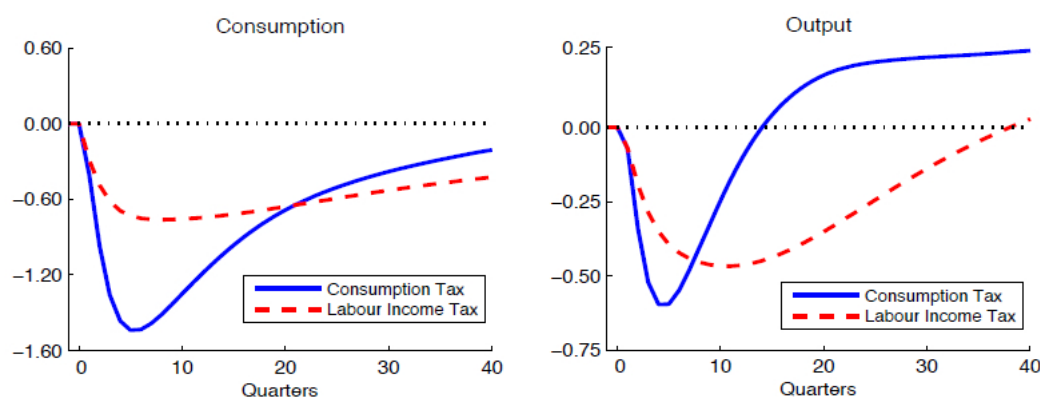


Figure 2.6: Impact of a fiscal consolidation in Coenen et al. (2008).

modeled as a consumption tax, and instead featured empirically plausible tax pass-through. This would presumably make the VAT the superior fiscal instrument also in the short run.

My findings are also potentially relevant for the impact of Fiscal Devaluations in theoretical models. Since the literature follows the conventional VAT modeling strategy (see Lipinska & Von Thadden, 2012; Hohberger & Kraus, 2016, Engler et al., forthcoming), a VAT increase – that is part of a Fiscal Devaluation – immediately reduces private consumption. Under empirically plausible pass-through dynamics this consumption decline would be significantly weaker.

Lastly, my results are important for the choice between using the standard VAT rate or reduced VAT rates as fiscal instrument. Benedek et al. (2015) report that tax pass-through is considerably faster and more comprehensive for the standard rate than for reduced rates. In light of my findings, reduced rates appear thus more suitable for fiscal consolidation, as they can be expected to have a weaker adverse impact on economic activity in the short run. By the same token, the standard rate is more appropriate to be lowered in order to stimulate the economy: as the benefit is more quickly passed on to consumers, the induced GDP expansion is stronger in the short run.³³

2.7 Robustness analysis

To examine the robustness of the results, Tables 2.3 and 2.4 (p. 29 and p. 30 in the appendix) report the same statistics as Table 2.2, but for variations in parameters and in the model specification. Rows labeled “rigorous modeling strategy” depict the results for the baseline parameters $\theta^r = 0.75$ and $\beta^r = 0.99$. As in Table 2.2, parentheses indicate the percentage reduction in rigorous VAT multipliers that make them as large as their consumption tax counterparts.

³³Baseline pass-through in my model is in line with the estimates of Benedek et al. (2015) for their full sample, so it corresponds to the average VAT pass-through across all types of VAT. Vegh & Vuletin (2015) report that reduced rates and standard rates are typically adjusted alongside: for seven of nine sample countries, the correlation between both rates is larger than 0.5 and statistically significant at the one percent level. In a strict sense, a change in the realistic VAT under the model’s baseline calibration can be thought of as a tax reform that changes both types of VAT, with weights corresponding to the respective type’s relative frequency in the sample of VAT changes by Benedek et al. (2015).

2.7.1 Exercise A: Introducing Rule-of-Thumb households

In this exercise, 40% of households are credit-constrained “Rule-of-Thumb” consumers, introduced by Galí et al. (2004).³⁴ The overall size of multipliers becomes larger and the differences across both model versions also increase slightly. Changes in disposable income of Rule-of-Thumb households translate to their full extent into changes in consumption, so a larger tax burden gives rise to an adverse feedback loop lowering consumption, output, and thereby income. In the short run this is more relevant under the conventional modeling approach because the tax burden is more swiftly passed on to consumers than under the rigorous modeling strategy.

2.7.2 Exercise B: Flexible wages

To obtain wage flexibility, the rigidity parameter of wages θ^w (see equation (2.31)) is set to a negligibly small value, which slightly reduces the overall size of multipliers. Under wage flexibility, nominal wages decline in the short-run as response to the fall in the MRS between consumption and leisure. This reduction in marginal costs leads to lower producer prices. The latter stabilizes output in the face of the consolidation, because it offsets some of the increase in consumer prices (the driver of the reduction in consumption), and because the implied deterioration in the terms of trade induces more export demand. The implications of wage flexibility for the differences in multipliers across both model versions are very modest.

2.7.3 Exercise C: Weaker elasticity of intertemporal substitution

This exercise considers $\gamma = 2$ instead of $\gamma = 1$ in the utility function (2.1), which lowers the elasticity of intertemporal substitution. We observe that multipliers are significantly smaller, but differences between both model versions decrease only slightly. The reason why multipliers are smaller is that intertemporal substitution induced by changes in consumer prices is the main channel by which a consolidation affects output.

2.7.4 Exercise D: Larger public sector and labor taxes

As of 2014, general government expenditure as share of GDP is on average as high as 49% in the Euro Area (source: Eurostat). To replicate this figure, we extend the model by a constant labor tax rate of 32% and increase government consumption G by the amount of the additional revenues.³⁵ This mildly changes the size of multipliers in both model versions, but does not significantly affect their differences across both versions.

2.7.5 Exercise E and F: Higher country weights in Taylor Rule

The baseline value $n = 0.01$ roughly matches the 2016 HICP country weights of Ireland, Greece and Portugal (1.4%, 2.4% and 2.2% respectively) and implies that the home country has a negligible weight in the union-wide inflation measure. Hence there is no significant reaction of monetary policy to inflation in the home country. To study the implications of higher country weights, exercise E considers $n = 0.11$ (which is in line with the HICP weight of Spain), and exercise F uses $n = 0.2$ (which roughly corresponds the weight of Italy and France, 17.6% and 20.7% respectively).³⁶ We observe that a higher country weight leads to smaller multipliers. To see why, recall that the decline in consumption is driven by the positive

³⁴The model description is available upon request.

³⁵The model description is available upon request.

³⁶All of these countries have a high debt-to-GDP ratio. In 2015, it is 93.8% in Ireland, 176.9% in Greece, 129% in Portugal, 99.2% in Spain, 132.7% in Italy, and 95.8% in France. Source: Eurostat.

deviation of the long-term real rate from the onset of the consolidation, and that this deviation results from the fall in consumer prices when the consolidation comes to an end. Responsive monetary policy means that this downward-reversion of consumer prices goes along with a decline in the nominal rate, which dampens the positive deviation in the real rate. Regarding the differences in multipliers across both model versions, a higher value of n does not significantly affect the results.

2.8 Conclusion

This paper analyzes the implications of empirically plausible tax pass-through dynamics for VAT multipliers. It is motivated by the fact that standard models in academic research as well as workhorse models of leading policy-making institutions implement the VAT as a consumption tax paid by consumers, which dramatically exaggerates the speed of tax pass-through relative to empirical evidence. I use a standard DSGE model to quantify the difference between VAT multipliers under the conventional modeling strategy and multipliers under a VAT modeling strategy that is rigorous in the sense that it features empirically plausible tax pass-through. The analysis shows that the conventional modeling strategy greatly overestimates the short-run impact of VAT changes: depending on the duration of the discretionary fiscal policy, one-year average multipliers and two-year average multipliers decline by about 50%-80% and 30%-60% respectively once we introduce empirically plausible VAT pass-through. Since the relative size of multipliers associated with different fiscal instruments is crucial for the design of discretionary fiscal policy packages, the accuracy of VAT multipliers obtained from theoretical models is highly relevant for policy advice. This is particularly true on the backdrop of the high debt levels in many developed countries, which make it necessary to assess alternative fiscal consolidation strategies.

The results of this paper also draw attention to the distinction between the VAT standard rate and VAT reduced rates as fiscal instruments. Since both are reported to differ in their pass-through dynamics, a more thorough analysis of their suitability as instrument for macroeconomic stabilization is a promising direction for future research. Finally, revisiting the implementation of the VAT could potentially overturn the results from the theoretical literature on the effectiveness of Fiscal Devaluations.

The technical novelty of the paper is a modeling strategy that allows to align VAT pass-through with empirical estimates. However, provided that a model features country-specific pricing equations, a technically inexpensive alternative to the proposed modeling strategy is to implement the VAT as a tax paid by intermediate good firms on their sales (discussed at the end of Section 2.3.2). This would make the respective model substantially better suited to derive tax multipliers for countries that use a European-style VAT rather than a US-style sales tax.

2.9 Appendix

Table 2.3: Robustness analysis (1/2)

		Impact multiplier	Peak multiplier	1 year	Average multipliers			20 years	Avg. adjustment duration +2 yrs.
					2 years	5 years			
Baseline model (for comparison)									
One year duration	Conventional mod. strat.	0.16	0.16	0.15	—	—	—	—	-0.05
—	Rigorous mod. strat.	0.03 (-83%)	0.05 (-69%)	0.04 (-73%)	—	—	—	—	-0.02 (-54%)
Two years duration	Conventional mod. strat.	0.15	0.15	0.15	0.14	—	—	—	-0.06
—	Rigorous mod. strat.	0.03 (-79%)	0.08 (-46%)	0.06 (-59%)	0.07 (-52%)	—	—	—	-0.04 (-36%)
Five years duration	Conventional mod. strat.	0.15	0.15	0.14	0.13	0.12	—	—	-0.08
—	Rigorous mod. strat.	0.03 (-79%)	0.10 (-30%)	0.06 (-56%)	0.08 (-38%)	0.09 (-25%)	—	—	-0.06 (-17%)
20 years duration	Conventional mod. strat.	0.14	0.14	0.13	0.12	0.10	0.09	—	-0.08
—	Rigorous mod. strat.	0.02 (-86%)	0.10 (-29%)	0.05 (-60%)	0.07 (-40%)	0.08 (-18%)	0.08 (-7%)	—	-0.08 (-4%)
Exercise A: Including Rule-of-thumb consumers									
One year duration	Conventional mod. strat.	0.20	0.20	0.20	—	—	—	—	-0.06
—	Rigorous mod. strat.	0.03 (-83%)	0.06 (-71%)	0.05 (-75%)	—	—	—	—	-0.03 (-57%)
Two years duration	Conventional mod. strat.	0.20	0.20	0.19	0.18	—	—	—	-0.08
—	Rigorous mod. strat.	0.04 (-79%)	0.10 (-50%)	0.07 (-60%)	0.08 (-54%)	—	—	—	-0.05 (-38%)
Five years duration	Conventional mod. strat.	0.19	0.19	0.17	0.15	0.13	—	—	-0.08
—	Rigorous mod. strat.	0.04 (-79%)	0.11 (-41%)	0.07 (-57%)	0.09 (-39%)	0.10 (-27%)	—	—	-0.07 (-18%)
20 years duration	Conventional mod. strat.	0.19	0.19	0.17	0.14	0.11	0.09	—	-0.09
—	Rigorous mod. strat.	0.04 (-80%)	0.12 (-37%)	0.07 (-58%)	0.09 (-41%)	0.09 (-20%)	0.09 (-8%)	—	-0.09 (-4%)
Exercise B: Flexible wages									
One year duration	Conventional mod. strat.	0.12	0.12	0.11	—	—	—	—	-0.03
—	Rigorous mod. strat.	0.02 (-85%)	0.03 (-74%)	0.03 (-75%)	—	—	—	—	-0.01 (-56%)
Two years duration	Conventional mod. strat.	0.12	0.12	0.09	0.09	—	—	—	-0.04
—	Rigorous mod. strat.	0.02 (-81%)	0.05 (-55%)	0.04 (-59%)	0.04 (-53%)	—	—	—	-0.03 (-36%)
Five years duration	Conventional mod. strat.	0.12	0.12	0.09	0.09	0.08	—	—	-0.06
—	Rigorous mod. strat.	0.02 (-81%)	0.07 (-36%)	0.04 (-55%)	0.05 (-36%)	0.06 (-24%)	—	—	-0.05 (-16%)
20 years duration	Conventional mod. strat.	0.11	0.11	0.09	0.09	0.08	0.08	—	-0.08
—	Rigorous mod. strat.	0.02 (-82%)	0.08 (-25%)	0.04 (-53%)	0.06 (-34%)	0.07 (-14%)	0.08 (-5%)	—	-0.07 (-2%)
Exercise C: Weaker elasticity of intertemporal substitution									
One year duration	Conventional mod. strat.	0.07	0.07	0.07	—	—	—	—	-0.02
—	Rigorous mod. strat.	0.01 (-82%)	0.02 (-67%)	0.02 (-72%)	—	—	—	—	-0.01 (-52%)
Two years duration	Conventional mod. strat.	0.07	0.07	0.06	0.06	—	—	—	-0.03
—	Rigorous mod. strat.	0.02 (-77%)	0.04 (-42%)	0.03 (-56%)	0.03 (-49%)	—	—	—	-0.02 (-33%)
Five years duration	Conventional mod. strat.	0.06	0.06	0.06	0.06	0.05	—	—	-0.04
—	Rigorous mod. strat.	0.02 (-77%)	0.05 (-24%)	0.03 (-52%)	0.04 (-34%)	0.04 (-22%)	—	—	-0.03 (-14%)
20 years duration	Conventional mod. strat.	0.06	0.06	0.06	0.05	0.05	0.05	—	-0.04
—	Rigorous mod. strat.	0.01 (-80%)	0.05 (-22%)	0.03 (-54%)	0.04 (-35%)	0.04 (-14%)	0.04 (-4%)	—	-0.04 (-1%)
Exercise D: Larger public sector and payroll taxes									
One year duration	Conventional mod. strat.	0.13	0.13	0.13	—	—	—	—	-0.04
—	Rigorous mod. strat.	0.02 (-83%)	0.04 (-68%)	0.04 (-73%)	—	—	—	—	-0.02 (-53%)
Two years duration	Conventional mod. strat.	0.13	0.13	0.13	0.13	—	—	—	-0.06
—	Rigorous mod. strat.	0.03 (-78%)	0.08 (-42%)	0.05 (-58%)	0.06 (-51%)	—	—	—	-0.04 (-35%)
Five years duration	Conventional mod. strat.	0.13	0.13	0.12	0.12	0.12	—	—	-0.08
—	Rigorous mod. strat.	0.03 (-77%)	0.11 (-16%)	0.06 (-53%)	0.08 (-36%)	0.09 (-24%)	—	—	-0.07 (-16%)
20 years duration	Conventional mod. strat.	0.12	0.12	0.12	0.11	0.11	0.11	—	-0.10
—	Rigorous mod. strat.	0.02 (-82%)	0.11 (-12%)	0.05 (-55%)	0.07 (-36%)	0.09 (-16%)	0.10 (-8%)	—	-0.09 (-6%)

Table 2.4: Robustness analysis (2/2)

		Impact multiplier	Peak multiplier	1 year	Average multipliers			Avg. adjustment duration +2 yrs.
					2 years	5 years	20 years	
Baseline model (for comparison)								
One year duration	Conventional mod. strat.	0.16	0.16	0.15	—	—	—	-0.05
—	Rigorous mod. strat.	0.03 (-83%)	0.05 (-69%)	0.04 (-73%)	—	—	—	-0.02 (-54%)
Two years duration	Conventional mod. strat.	0.15	0.15	0.15	0.14	—	—	-0.06
—	Rigorous mod. strat.	0.03 (-79%)	0.08 (-46%)	0.06 (-59%)	0.07 (-52%)	—	—	-0.04 (-36%)
Five years duration	Conventional mod. strat.	0.15	0.15	0.14	0.13	0.12	—	-0.08
—	Rigorous mod. strat.	0.03 (-79%)	0.10 (-30%)	0.06 (-56%)	0.08 (-38%)	0.09 (-25%)	—	-0.06 (-17%)
20 years duration	Conventional mod. strat.	0.14	0.14	0.13	0.12	0.10	0.09	-0.08
—	Rigorous mod. strat.	0.02 (-86%)	0.10 (-29%)	0.05 (-60%)	0.07 (-40%)	0.08 (-18%)	0.08 (-7%)	-0.08 (-4%)
Exercise E: 11% weight and different inflation measure								
One year duration	Conventional mod. strat.	0.16	0.16	0.13	—	—	—	-0.04
—	Rigorous mod. strat.	0.03 (-83%)	0.04 (-73%)	0.04 (-73%)	—	—	—	-0.02 (-53%)
Two years duration	Conventional mod. strat.	0.16	0.16	0.13	0.13	—	—	-0.06
—	Rigorous mod. strat.	0.03 (-78%)	0.07 (-52%)	0.06 (-57%)	0.06 (-51%)	—	—	-0.04 (-35%)
Five years duration	Conventional mod. strat.	0.15	0.15	0.12	0.12	0.11	—	-0.07
—	Rigorous mod. strat.	0.03 (-78%)	0.10 (-35%)	0.06 (-53%)	0.08 (-35%)	0.08 (-24%)	—	-0.06 (-15%)
20 years duration	Conventional mod. strat.	0.14	0.14	0.12	0.11	0.10	0.09	-0.08
—	Rigorous mod. strat.	0.03 (-82%)	0.09 (-34%)	0.05 (-55%)	0.07 (-36%)	0.08 (-16%)	0.09 (-6%)	-0.08 (-3%)
Exercise F: 20% weight and different inflation measure								
One year duration	Conventional mod. strat.	0.16	0.16	0.12	—	—	—	-0.04
—	Rigorous mod. strat.	0.03 (-83%)	0.04 (-77%)	0.03 (-72%)	—	—	—	-0.02 (-52%)
Two years duration	Conventional mod. strat.	0.16	0.16	0.12	0.11	—	—	-0.05
—	Rigorous mod. strat.	0.04 (-78%)	0.07 (-58%)	0.05 (-55%)	0.06 (-50%)	—	—	-0.03 (-34%)
Five years duration	Conventional mod. strat.	0.16	0.16	0.11	0.11	0.10	—	-0.07
—	Rigorous mod. strat.	0.04 (-77%)	0.09 (-40%)	0.06 (-50%)	0.07 (-33%)	0.08 (-23%)	—	-0.06 (-14%)
20 years duration	Conventional mod. strat.	0.15	0.15	0.11	0.10	0.10	0.10	-0.09
—	Rigorous mod. strat.	0.03 (-79%)	0.10 (-34%)	0.05 (-51%)	0.07 (-33%)	0.08 (-14%)	0.09 (-5%)	-0.09 (-3%)

SECOND ESSAY

Fiscal Devaluation in a Monetary Union

Joint work with Philipp Engler, Giovanni Ganelli and Juha Tervalla

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Given that exchange rate devaluations are no longer available in a monetary union, fiscal devaluations are one potential way to address divergence in competitiveness and trade imbalances. Employing a DSGE model calibrated to the euro area we quantify the international effects of a fiscal devaluation implemented as a revenue-neutral shift from employers' social contributions to the Value Added Tax. We find that a fiscal devaluation carried out in the South has a strong positive effect on output, which is five times larger than under a wage tax cut. However, the effect on the trade balance and the real exchange rate is mild. The negative effect on the North's output is weak.

3.1 Introduction

Between 1999 and the onset of the economic crisis in 2008 real exchange rates in various countries, such as Greece, Ireland, Italy, Portugal and Spain, have appreciated relative to the rest of the euro area (see Figure 3.1). This divergence in competitiveness was reflected in the emergence of external imbalances within the euro area, with some countries—such as Austria, Belgium, Finland, Germany, Luxembourg and The Netherlands—accumulating current account surpluses, and others—such as Greece, Ireland, Italy, Portugal and Spain—accumulating deficits. Figure 3.2 below shows the dynamics of the aggregate current account balances of the North (Austria, Belgium, Finland, France, Germany, Luxembourg and The Netherlands) and those of the South (Greece, Ireland, Italy, Portugal and Spain).¹ The loss of competitiveness of the South and the attendant emergence of within-union external imbalances are widely regarded as important factors contributing to the euro area crisis.

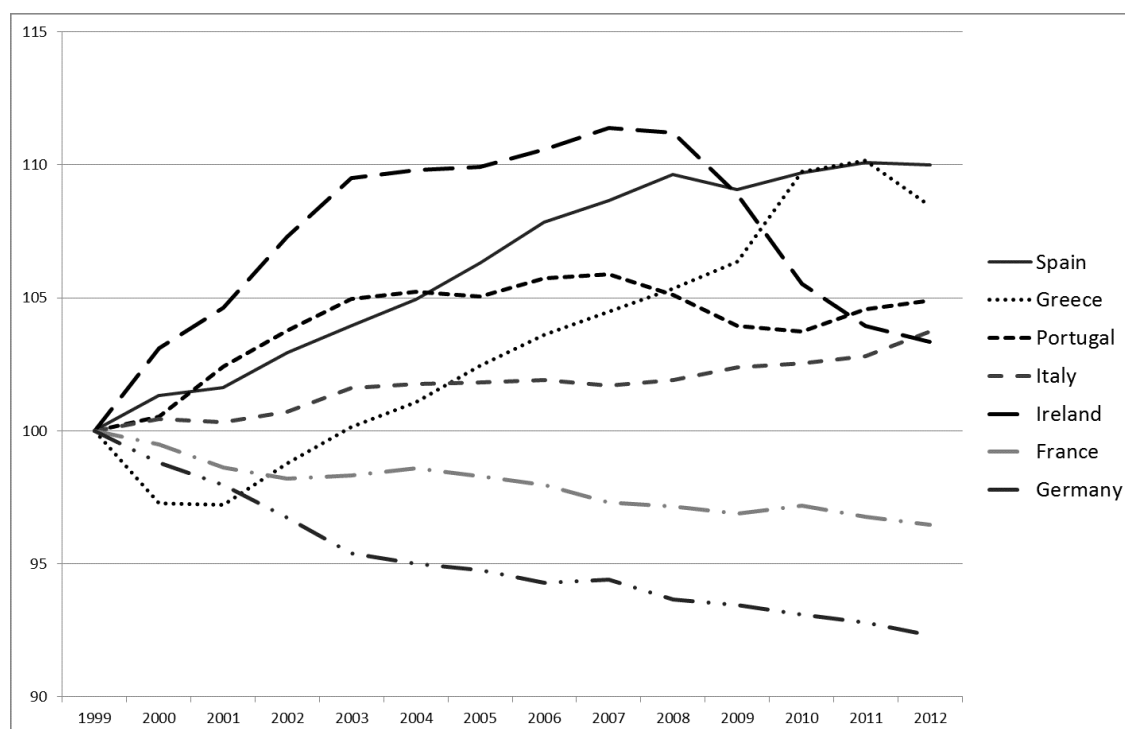


Figure 3.1: Real Effective Exchange Rate (deflator: consumer price indices - 17 trading partners) in selected euro area countries 1/. Source: Eurostat (2013).

An increase denotes an appreciation of the real exchange rate.

Correcting within-union imbalances is a prerequisite for overcoming the euro area crisis and putting the euro area economy back on a sustainable path. Given that exchange rate devaluations are no longer available to individual countries in the euro area, one potential way to address such imbalances is by using fiscal policy, which can, under certain circumstances, replicate the impact of exchange rate devaluations.

The idea of ‘fiscal devaluations’ is not a new one, and goes back to Keynes (1931), who stated:

¹ Since we have included Ireland in this group, a more precise denomination would be ‘Ireland and Southern European countries’ but in what follows we will use ‘the South’ for simplicity.

SECOND ESSAY ON FISCAL DEVALUATIONS

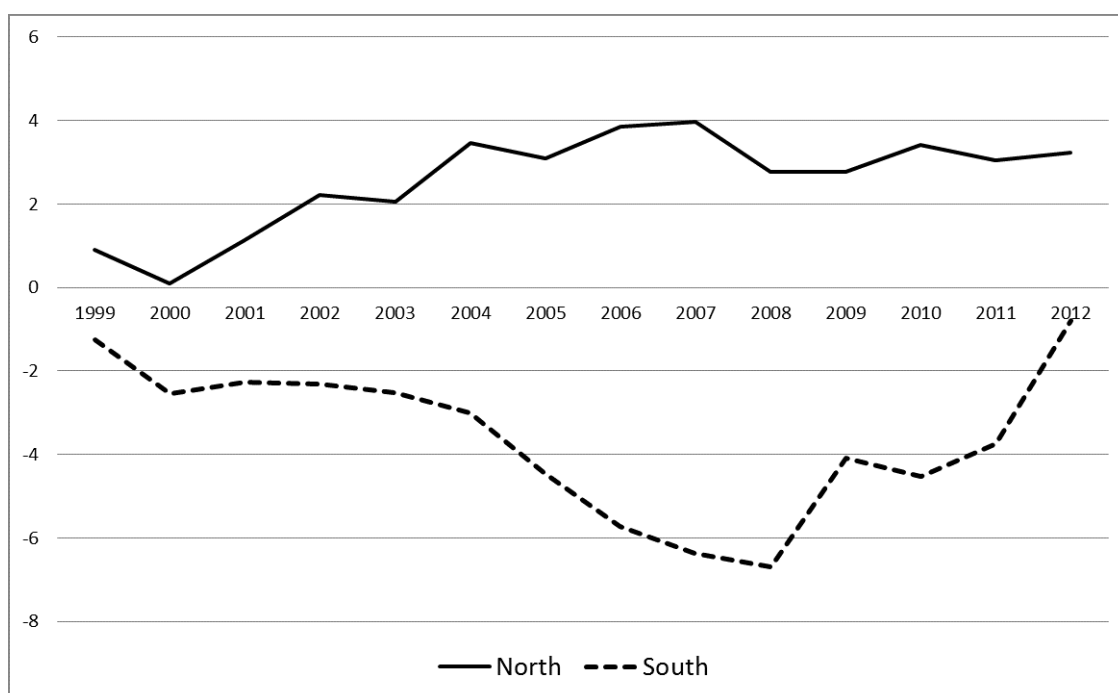


Figure 3.2: Current account surplus (% of GDP) of the North and the South. Source: WorldBank (2013)

Precisely the same effects as those produced by a devaluation of sterling by a given percentage could be brought about by a tariff of the same percentage on all imports together with an equal subsidy on all exports, except that this measure would leave sterling international obligations unchanged in terms of gold.

In its modern incarnation, Keynes' idea can be implemented not by using tariffs and subsidies—which would be inconsistent with free trade agreements in economic and monetary unions—but rather by a policy mix entailing a reduction in employers' social contributions and an increase in the Value Added Tax (VAT).² Since the latter is reimbursed to exporters and levied on importers, the overall effect of such fiscal reform is to make domestic producers more competitive.

In this paper we develop a two-country New Keynesian model, where the two countries are calibrated to represent the North and the South of the euro area. We use our model to analyze the international transmission of a revenue-neutral fiscal devaluation implemented in the South, which we model as a shift from employers' social contributions toward the VAT. The motivation for our chosen approach is that the size of the South of the euro area is large enough to affect the North. More importantly, the goal of a fiscal devaluation in the South is to correct its loss of competitiveness relative to the North and the current account imbalance within the euro area. Our approach highlights international transmission channels and allows us to analyze not only the effects of fiscal devaluations in the South on its own economies, but also the impact on economic variables in the North.

Although several existing papers have looked at fiscal devaluations, most of them use small open economy frameworks, and as such, they cannot analyze the international spillover effects of fiscal devaluations. Unlike these papers, our two-country framework is well equipped to address such issues.

²CPB (2013), Section 2 surveys the literature on fiscal devaluations.

As we explain below, our paper also differentiates itself from the only three contributions to this literature that we know of, which use a two-country framework (Farhi et al., 2014; Franco, 2010; Lipinska & Von Thadden, 2012). In particular, our paper's main contribution is to *quantitatively* address the *international* transmission of a “pure” fiscal devaluation and the role of sticky wages in the transmission of fiscal devaluations. The term “pure fiscal devaluation” here refers to a fiscal reform in which the increase in the VAT is compensated by a reduction in social contributions paid by employers, not by a reduction in the labor income tax.³

We use a model of a monetary union with imperfect competition in the goods and labor markets. As mentioned, we calibrate the two countries of the model to represent the South and the North of the euro area. In particular, the relative sizes of the two countries in the model are set to match the relative GDPs of the South and the North. We model a fiscal devaluation as a revenue-neutral shift from employers' social contributions to the VAT. The sizes of tax shocks in the South are set in such a way that VAT revenues are increased permanently by 1 percent of GDP, while SCR revenues are reduced permanently by 1 percent of GDP.

A reduction in the social contribution rate (SCR) in the South implies lower producer prices, resulting in a reduction of relative prices of the South's goods compared with the North's goods. This causes a shift in demand away from the North's goods and toward the South's goods, which results in an increase in output in the South. Due to the Calvo-pricing mechanism, after the initial reaction, a larger fraction of firms in the South become able to lower its prices. This implies an even stronger expenditure-switching effect after a few quarters. However, the positive effect from lower social contributions on the South's output is mitigated by the impact of the VAT increase on the South's prices and the ensuing price-wage dynamics. Immediately after a fiscal devaluation, wages start to adjust upwards in the South. Given imperfect competition in the labor market in our model, a higher price level, caused by the increase in the VAT rate, implies that labor unions require higher nominal wages. Real marginal costs therefore start to adjust toward the original, pre-reform level and the positive effect on output gradually peters out. However, this effect is mitigated to the extent that the wage adjustment process occurs in a staggered fashion. We show that an empirically plausible degree of wage staggering a la Calvo ensures a fall in prices and a temporarily sizable increase in output. Even in the long term, however, the positive effect of the reduction in SCR social contributions on output still dominates the negative effect of the increase in the VAT, and a revenue-neutral fiscal devaluation still has a small positive effect on the South's output in the long term.

As a result of the effects described above, the South's output displays a hump-shaped response. Under the benchmark parameterization, a permanent fiscal devaluation increases the level of output in the South by 1.2 percent in the fourth quarter. Our sensitivity analysis confirms the main result, and shows that the peak effect on the South's level of output is - assuming sticky wages — in the 0.8-1.6 percent range, depending on the parameterization.

We also show that a fiscal devaluation has quite limited impact on the trade balance. In the South, income goes up more in the short term than in the long term. This implies that in the short-term the South's households are temporarily richer, and therefore they save by accumulating net external assets. The South's trade balance improves by 0.3 percent of GDP in the short term.

Our results are in line with those of the small open economy models used by the BOP (2011) and the ECB (2012), which find that a fiscal devaluation, of 1 percent of GDP, depreciates the real exchange rate (0.3 percent), increases the level of output (0.2-0.6 percent) and improves the current account balance (0.1-0.6 percent of GDP). We find a stronger effect on output in the short term, while the effects on the

³Farhi et al. (2014) use a two-country model to show that a fiscal devaluation can replicate the effects of a nominal exchange rate devaluation, but they numerically evaluate the effects of a fiscal devaluation on a small open economy (Spain). In addition, they do not analyze the role of sticky wages in the transmission of fiscal shocks. Lipinska & Von Thadden (2012) model fiscal devaluation as a reduction in labor income taxes, rather than in SCR (see more detailed discussion below). As such, this is not a “pure” fiscal devaluation. Franco (2010) develops a two-country model of a monetary union, but calibrates it to Portugal, virtually ignoring the international transmission of fiscal devaluations

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trade balance and the real exchange rate are within range of earlier results.

Lipinska & Von Thadden (2012) is the paper most directly related to ours. They use a New Keynesian two-country model of a monetary union with different degrees of financial integration. Our paper differs from theirs in three dimensions. First, they model a fiscal devaluation as a permanent increase in the VAT and a reduction in the labor income tax rate, rather than as a reduction in the SCR, as we do. Second, they do not calibrate their model for a specific country or a group of countries, whereas we calibrate the two countries to the relative sizes of the South and the North of the euro area. Finally, unlike them, we analyze the impact of fiscal devaluations not only on output, but also on the trade balance.

Lipinska & Von Thadden (2012) find that, in a region whose size is half of a monetary union, fiscal devaluations tend to be ineffective: they find that the peak effect on domestic output is only 0.05-0.15 percent, compared to 0.9-1.5 percent in our model. The difference between our results and theirs is due to the fact that, as mentioned above, their fiscal devaluation is modeled as a permanent increase in the VAT compensated by a reduction in the labor income tax rate. As such, this is not a “pure” fiscal devaluation because, unlike a reduction in the SCR, a reduction in the labor income tax does not necessarily imply competitiveness gains for domestic goods. One of our key findings is therefore that a fiscal devaluation in a large country, if properly modeled as a reduction in SCRs, and assuming a realistic degree of wage stickiness, can substantially increase output.

Regarding international transmission effects, we find that a fiscal devaluation in the South decreases output in the North in the short term. As mentioned earlier, a fiscal devaluation in the South causes a shift in demand away from the North’s goods, which results in a decrease in its output. However, the peak effect (the most negative effect) is only -0.1 percent.

De Mooij & Keen (2012) use a Vector Autoregression (VAR) methodology to analyze the effects of changes of the VAT and the SCR on net exports. Their results suggest that, within the euro area, a fiscal devaluation might increase the trade balance quite sizably in the short term. Their empirical results imply that raising the VAT rate by 1 percentage points and reducing the SCR rate by 1.7—the same policy that we calibrate in our model to achieve a 1 percent of GDP redistribution in taxation in the South—improves net exports by 0.4 percent of GDP. The results of our calibration are broadly consistent with these empirical estimates regarding the effect on the trade balance. In our model, under the benchmark parameterization, the trade balance of the South improves by 0.3 percent of GDP, a slightly weaker impact than the one found by De Mooij & Keen (2012).

Overall, we find that a fiscal devaluation in the South depreciates its real exchange rate, increases its output and improves its trade balance. However, the advantageous effects of a fiscal devaluation should not be overplayed. A fiscal devaluation of 1 percent of GDP carried out by the South depreciates the real exchange rate by 0.3 percent and improves the trade balance by 0.3 percent of GDP, which are quite small effects. Figure 3.2 shows that the current account deficit in the South was roughly 1 percent of GDP in 2012. We show that a fiscal devaluation of roughly 4 percent of GDP is needed to correct—temporarily—the 1 percent trade balance deficit in the South. This would imply that the VAT rate needs to be increased by 4 percentage points and it may be difficult to raise VAT rates by such a large amount swiftly. In addition, a fiscal devaluation of 4 percent of GDP depreciates the real exchange rate of the South only by 1.2 percent. Our findings suggest that a fiscal devaluation alone would not be sufficient to correct the divergence in competitiveness and the current account imbalance between the South and the North of the euro area. Although a fiscal devaluation can be a useful reform to make progress in this direction, in order to be successful, it would need to be part of a wider package of policy reforms aimed at increasing the competitiveness of the South, including for example product and labor market reforms and wage moderation.

The rest of the paper is organized as follows. Section 3.2 presents the model. Section 3.3 discusses the parameterization. Section 3.4 analyzes the international transmission effects of the South's fiscal devaluation. Section 3.5 concludes the paper.

3.2 The Model

In this section, we develop a New Keynesian open-economy model. The model consists of two regions that have formed a monetary union, infinitely-lived households, imperfect competition and nominal rigidities in goods and labor markets, a central bank and a fiscal authority. The two regions represent the South and the North of the euro area. We assume a continuum of households and normalize the size of the euro area to one. Households are indexed by $i \in [0, 1]$ and the relative size of the South (the North) is $1 - n(n)$.

3.2.1 Households

Preferences

In the baseline model, all households are identical and we present only the equations for the South if the equations are symmetric across regions. Households in the South maximize their intertemporal utility function

$$U_t^R = \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \left\{ \log C_{t+k} - \frac{(N_{t+k})^{1+\phi}}{1+\phi} \right\}, \quad (3.1)$$

where \mathbb{E}_t is the expectations operator, β is the discount factor, C_t is a consumption index, N_t is the households' labor supply and $1/\phi$ is the Frisch elasticity of labor supply.

The consumption index is⁴

$$C_t = \left\{ (1 - \omega)^{\frac{1}{\sigma}} (C_t^S)^{\frac{\sigma-1}{\sigma}} + \omega^{\frac{1}{\sigma}} (C_t^N)^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{1-\sigma}} \quad (3.2)$$

where C_t^S and C_t^N respectively denote the consumption by households in the South of the South's and the North's goods, σ is the elasticity of substitution between the South's and the North's goods (cross-country substitutability, for short) and ω is the steady state share of imported goods in the consumption basket of the South.

The consumption of the South's and the North's goods C_t^S and C_t^N are defined as

$$C_t^S = \left[(1 - n)^{-\frac{1}{\epsilon}} \int_n^1 (c_t^S(i))^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}, C_t^N = \left[n^{-\frac{1}{\epsilon}} \int_0^n (c_t^N(i))^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}$$

where $c_t^S(i)$ and $c_t^N(i)$ respectively denote consumption of the differentiated goods produced in the South and in the North by households in the South and ϵ is the elasticity of substitution between goods produced in the same region. We refer to ϵ as the within-country substitutability.

Given the consumption indexes, the South's demands for the representative good i produced in the South and in the North are

$$c_t^S(i) = \frac{1 - \omega}{1 - n} \left(\frac{p_t^S(i)}{P_t^S} \right)^{-\epsilon} \left(\frac{P_t^S}{P_t} \right)^{-\sigma} C_t, \quad$$

⁴The household in the North has the following consumption index (the North's variables are denoted by an asterisk): $C_t^* = \left\{ (1 - \omega^*)^{\frac{1}{\sigma}} (C_t^{*N})^{\frac{\sigma-1}{\sigma}} + (\omega^*)^{\frac{1}{\sigma}} (C_t^{*S})^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{1-\sigma}}$

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$$c_t^N(i) = \frac{\omega}{n} \left(\frac{P_t^N(i)}{P_t^N} \right)^{-\epsilon} \left(\frac{P_t^N}{P_t} \right)^{-\sigma} C_t \quad ,$$

respectively, where $P_t^S(i)$ is the price of the South's good i , $P_t^N(i)$ is the price of the North's good i and $P_t^S(P_t^N)$ is the price index corresponding to the South's (North's) consumption basket C_t^S (C_t^N) and P_t is the South's consumer price index. They are defined as follows:

$$P_t^S = \left((1-n)^{-1} \int_n^1 p_t^S(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}} \quad ,$$

$$P_t^N = \left(n^{-1} \int_0^n p_t^N(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}} \quad ,$$

$$P_t = \left((1-\omega) (P_t^S)^{1-\sigma} + \omega (P_t^N)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \quad .$$

The corresponding price indexes for the North are defined analogously. For future reference, we define the South's terms of trade, denoted by S_t , as the relative price of the North's goods in terms of the South's goods

$$S_t = \frac{P_t^S}{P_t^N} \quad .$$

In addition, the consumer-price-index-based real exchange rate, denoted by RER , is defined as

$$RER_t = \frac{P_t}{P_t^*} \quad ,$$

where P_t^* is the North's consumer price index.

Budget constraints and consumption decisions

The budget constraint of the South's household is given by

$$B_{t+1} + (1 + \tau_t^{VAT}) P_t C_t = R_{t-1} B_t + W_t N_t + \Pi_t + T_t \quad . \quad (3.3)$$

B_t denotes the holding of nominal bonds at the beginning of period t , τ_t^{VAT} is the VAT rate, R_{t-1} is the gross return on bonds between $t-1$ and t , W_t is the economy-wide nominal wage paid to the household, Π_t denotes nominal profits of the South's firms and T_t denotes transfers from the government.

The optimal consumption paths are governed by the following Euler equations:

$$R_t^{-1} = \beta \mathbb{E}_t \left\{ \frac{C_t}{C_{t+1}} \frac{P_t}{P_{t+1}} \frac{1 + \tau_t^{VAT}}{1 + \tau_{t+1}^{VAT}} \right\} \quad , \quad (3.4)$$

$$(R_t^*)^{-1} = \beta \mathbb{E}_t \left\{ \frac{C_t^*}{C_{t+1}^*} \frac{P_t^*}{P_{t+1}^*} \frac{1 + \tau_t^{*VAT}}{1 + \tau_{t+1}^{*VAT}} \right\} \quad .$$

A simple way to render the model stationary is to assume that the domestic interest rate is increasing in the level of net foreign debt (Schmitt-Grohé & Uribe, 2003). We include a risk premium for the interest rate parity condition that forces external debt in the long term to return to the initial level. The interest parity condition with risk premium is given by

$$R_t = R_t^* - \psi(\exp(B_t) - 1) \quad ,$$

where $\psi(\exp(B_t) - 1)$ is the risk premium.

Aggregate demand and the trade balance

Total demand for the South's good i is the sum of the demand in South and in the North, as follows:

$$Y_t(i) = \left(\frac{p_t^S(i)}{P_t^S} \right)^{-\epsilon} \left[(1 - \omega) \left(\frac{P_t^S}{P_t} \right)^{-\sigma} C_t + \frac{n}{1-n} \omega^* \left(\frac{P_t^S}{P_t^*} \right)^{-\sigma} C_t^* \right].$$

Defining $Y_t^S \equiv (1 - \omega) \left(\frac{P_t^S}{P_t} \right)^{-\sigma} C_t + \frac{n}{1-n} \omega^* \left(\frac{P_t^S}{P_t^*} \right)^{-\sigma} C_t^*$ as total consumption of the bundle containing South's goods, we get the aggregate demand for good i :

$$Y_t(i) = \left(\frac{p_t^S(i)}{P_t^S} \right)^{-\epsilon} Y_t^S \quad (3.5)$$

One idea of a fiscal devaluation is to improve the trade balance. For future reference, we define the real trade balance (TB), expressed in terms of the domestic goods bundle, as follows:

$$\frac{TB_t}{P_t^S} = Y_t - \frac{P_t}{P_t^S} C_t \quad .$$

Wage setting and employment

Typical features of European labor markets are a strong influence of labor unions and sticky wages. We therefore assume imperfect competition in the labor market and sticky wages. Workers supply a differentiated and imperfectly substitutable input to firms. Workers delegate wage setting to type-specific labor unions that exploit the market power in wage setting.

We introduce wage rigidities in the form of staggered nominal wage setting à la Calvo (1983). A labor union representing type z workers may reset its wages in any given period with a probability $1 - \theta_w$, independently of the amount of time since the last wage adjustment. Therefore, labor union z 's objective is given by

$$\max_{W_t(z)} \sum_{k=0}^{\infty} \beta^k \theta_w^k \mathbb{E}_t \left\{ \frac{1}{C_{t+k}} \frac{W_t(z)}{(1 + \tau_t^{VAT}) P_{t+k}} N_{t+k|t}(z) - \frac{N_{t+k|t}^{1+\phi}(z)}{1 + \phi} \right\} \quad , \quad (3.6)$$

where $N_{t+k|t}(z)$ is the employment level of z type workers in period $t + k$ and whose union is able to reset the type-specific wage rate $W_t(z)$ in period t . In setting wages, the labor union takes into account the firms' labor demand. Firm i employs $N_t(i, z)$ hours of all labor types z and aggregates them to the labor index $N_t(i)$ given by

$$N_t(i) = \left[(1 - n)^{-\frac{1}{\epsilon_w}} \int_n^1 N_t(i, z)^{\frac{\epsilon_w - 1}{\epsilon_w}} dz \right]^{\frac{\epsilon_w}{\epsilon_w - 1}} \quad , \quad (3.7)$$

where ϵ_w is the elasticity of substitution between different types of labor. Equation (3.7) is used to derive firm i 's demand for labor-type z , to give

$$N_t(i, z) = \frac{1}{1 - n} \left(\frac{W_t(z)}{W_t} \right)^{-\epsilon_w} N_t(i) \quad , \quad (3.8)$$

where W_t is the average wage level in the South, which is

$$W_t = \left[\frac{1}{1 - n} \int_n^1 (W_t(z))^{1 - \epsilon_w} dz \right]^{\frac{1}{1 - \epsilon_w}} \quad . \quad (3.9)$$

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Aggregation of the firm-specific demand functions over all firms yields the aggregate demand for labor type z , as follows:

$$\int_n^1 N_t(i, z) di \equiv N_t(z) = \left(\frac{W_t(z)}{W_t} \right)^{-\epsilon_w} \frac{1}{1-n} \int_n^1 N_t(i) di \quad . \quad (3.10)$$

The labor union maximizes equation (3.6) while taking into account equation (3.10). The first-order condition is

$$\sum_{k=0}^{\infty} \beta^k \theta_w^k \mathbb{E}_t \left\{ N_{t+k|t}(z) \left(\frac{1}{C_{t+k}} \frac{W_t^O}{(1 + \tau_t^{VAT}) P_{t+k}} - \frac{\epsilon_w}{\epsilon_w - 1} (N_{t+k|t}(z))^{\phi} \right) \right\} = 0 \quad , \quad (3.11)$$

where W_t^O is the optimal wage set by unions that reset their wages in period t . In the optimum, the weighted average of the marginal utility of the real wage, which is implied by setting $W_t(z)$ today, equals the average marginal disutility from working an extra hour.

The structure of wage setting implies that in each period a fraction of labor unions, $1 - \theta_w$, set a new wage, and the remaining fraction keep their wages unchanged. This implies that the aggregate wage index is

$$W_t = \left[\theta_w (W_{t-1})^{1-\epsilon_w} + (1 - \theta_w) (W_t^O)^{1-\epsilon_w} \right]^{\frac{1}{1-\epsilon_w}} \quad . \quad (3.12)$$

Aggregate employment N_t is the sum over all firms i and types of labor z , as follows

$$N_t \equiv \frac{1}{1-n} \int_n^1 \int_n^1 N_t(i, z) di dz \quad . \quad (3.13)$$

Employing the definitions of price-dispersion $s_t^p \equiv \frac{1}{1-n} \int_n^1 \left(\frac{P_t(i)}{P_t^S} \right)^{-\epsilon} di \geq 1$ and wage-dispersion $s_t^w \equiv \frac{1}{1-n} \int_n^1 \left(\frac{W_t(z)}{W_t} \right)^{-\epsilon_w} dz \geq 1$, as well as total demand for good i (equation (5)) and the linear production function introduced below (equation (15)), it can easily be shown that aggregate employment is governed by

$$N_t = s_t^p s_t^w Y_t \quad . \quad (3.14)$$

We see that in the presence of wage or price dispersion, one unit of consumption of the domestic bundle requires more than one unit of aggregate employment, due to inefficiencies caused by price and wage rigidities.

3.2.2 Firms and price setting

The production function of the typical firm i is

$$Y_t(i) = N_t(i) \quad , \quad (3.15)$$

where $Y_t(i)$ is firm i 's output and $N_t(i)$ is firm i 's effective employment (net of inefficiencies due to wage dispersion), specified in equation (3.7).

We assume that the payroll tax is paid by firms, and we refer to it as social contributions. Firm i 's profits are given by

$$\Pi_t(i) = P_t^S(i) Y_t(i) - (1 + \tau_t^{SCR}) \int_n^1 W_t(z) N_t(i, z) dz \quad ,$$

where τ_t^{SCR} is the social contribution rate (SCR). Employing firm i 's demand for labor-type z (equation (3.8)) and a wage-dispersion index $sw_t \equiv \frac{1}{1-n} \int_n^1 \left(\frac{W_t(z)}{W_t} \right)^{1-\epsilon_w} dz$, we can express profits as follows:

$$\Pi_t(i) = P_t^S(i) Y_t(i) - (1 + \tau_t^{SCR}) sw_t W_t N_t(i)$$

3.2. THE MODEL

Wage dispersion ($sw_t > 1$) implies an inefficient allocation in the employment of different types of labor, which increases the total amount of labor required to produce a given amount of output. A higher wage bill lowers profits for a given amount of output.

We introduce price rigidities in the form of staggered price setting à la Calvo (1983). Each firm may reset its price with a probability $1 - \theta_p$, independent of the time elapsed since the last adjustment and independent of other firms. With Calvo pricing, firm i seeks to maximize the discounted value of expected profits

$$\max_{P_t(i)} \mathbb{E}_t \sum_{k=0}^{\infty} \theta_p^k Q_{t,t+k} \Pi_{t+k}(i) \quad ,$$

where $Q_{t,t+k} \equiv \beta^k \mathbb{E}_t \left\{ \frac{C_t}{C_{t+k}} \frac{P_t}{P_{t+k}} \frac{1+\tau_t^{VAT}}{1+\tau_{t+k}^{VAT}} \right\}$ is a stochastic discount factor between period t and period $t+k$. The first-order condition for the firm's maximization problem is

$$\mathbb{E}_t \sum_{k=0}^{\infty} \theta_p^k Q_{t,t+k} Y_{t,t+k} \left[P_t^O - \frac{\epsilon}{\epsilon - 1} MC_{t+k} \right] = 0 \quad , \quad (3.16)$$

where P_t^O is the optimal price in period t , $Y_{t,t+k}$ is the level of period $t+k$ output produced by the firms that re-set their price in period t and MC_t is the marginal cost, defined as

$$MC_t = (1 + \tau_t^{SCR}) W_t \frac{1}{1-n} \int_n^1 \left(\frac{W_t(z)}{W_t} \right)^{1-\epsilon_w} dz \quad .$$

Alternatively, using the definition of wage-dispersion, the marginal cost can be expressed as follows:

$$MC_t = (1 + \tau_t^{SCR}) s_t^w W_t \quad . \quad (3.17)$$

The presence of wage-dispersion ($s_t^w > 1$) implies an inefficient usage of labor types. This increases the amount of labor required to produce an additional unit of output and thereby marginal costs.

Aggregate prices and aggregate supply

With Calvo pricing, the price index of the South's goods is

$$P_t^S = \left[\theta_p (1-n)^{-1} \int_n^1 (P_{t-1}(i))^{1-\epsilon} di + (1-\theta_p)(P_t^O)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \quad . \quad (3.18)$$

In equation (3.18) the integral contains only the prices of the South's goods whose prices are not allowed to be reset in period t . From the law of large numbers, for those firms, the average price P_{t-1}^S prevails and their mass equals θ_p , so that the price index becomes

$$P_t^S = \left[\theta_p (P_{t-1}^S)^{1-\epsilon} + (1-\theta_p)(P_t^O)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \quad . \quad (3.19)$$

Equations (3.8), (3.10)-(3.14), (3.16), (3.17) and (3.19) determine aggregate supply.

3.2.3 Fiscal and monetary policy

We assume that all government spending is for public transfers to households, which can be financed through the VAT and social contributions. We therefore abstract from government consumption. The budget constraint of the government is given by

$$\tau_t^{VAT} P_t C_t + \tau_t^{SCR} W_t N_t = T_t \quad .$$

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The first part of the left side of the above equation is tax revenue from value added taxation and the second part is social contribution tax revenue.

We assume that the VAT and SCR tax rates follow AR(1) processes

$$\begin{aligned}\tau_t^{VAT} &= \rho^{VAT} \tau_{t-1}^{VAT} + \varepsilon_t^{VAT} \quad , \\ \tau_t^{SCR} &= \rho^{SCR} \tau_{t-1}^{SCR} + \varepsilon_t^{SCR} \quad ,\end{aligned}$$

where ρ^{VAT} and $\rho^{SCR} \in [0, 1]$ and ε_t^{VAT} and ε_t^{SCR} are zero mean white-noise processes that represent unexpected changes to tax rates.

We assume that the central bank of the euro area follows a Taylor-type interest rate rule with interest rate smoothing. The central bank responds to euro area inflation, which is the population-weighted average of domestic inflation. Lipinska & Von Thadden (2012) show that the short-term effects of a shift in taxation depend on whether the monetary policy rule is specified in terms of pre-tax or after-tax consumer price inflation. We believe that it is reasonable to assume—in the current economic situation—that the central bank would not react to the South's one-off inflation caused by an increase in the VAT rate. The interest rate without interest rate smoothing, denoted by R_t^{WS} , is determined by the following monetary policy rule

$$R_t^{WS} = \beta^{-1} \left(\left(\frac{P_t^S}{P_{t-1}^S} \right)^{1-n} \left(\frac{P_t^N}{P_{t-1}^N} \right)^n \right)^{\alpha_\pi} ,$$

where the coefficient α_π is non-negative and chosen by the central bank. The actual interest rate of the euro area, denoted by R_t , is

$$R_t = (R_t^{WS})^{1-\rho^R} (R_{t-1})^{\rho^R} ,$$

where $\rho^R \in (0, 1)$ captures the degree of interest rate smoothing.

3.3 Parameter values

The parameterization of the model, summarized in Table 3.1, is chosen to match the features of the South and the North of the euro area. The model, however, is solved around the steady state where initial net foreign assets are zero. Periods are interpreted as quarters and the discount factor is set to 0.99. The relative size of the South, $1 - n$, is set to match the relative GDPs of the regions. According to the WorldBank (2013), the relative size of the South's output in 2011 was 0.34. We therefore set $1 - n = 0.34$. The labor supply parameter, ϕ , is set to one. This implies that the Frisch elasticity of labor supply is one, a value consistent with Kimball & Shapiro (2008a).

The coefficient (α_π) in the monetary policy rule is set to 1.5, based on Taylor (1993). As emphasized by Lipinska & Von Thadden (2012), empirical DSGE models of the euro area show a high degree of interest rate smoothing. The degree of interest rate smoothing (ρ^R) is set to 0.95, as in Lipinska & Von Thadden (2012). The risk premium in the interest rate parity (ψ) is set to 0.000001. A non-zero risk premium forces the net level of foreign debt to eventually revert to its initial level, thereby inducing stationarity of the model. This reversion occurs a very long time after the implementation of a fiscal devaluation due to the very low value of the risk premium. As a result, the reversion has negligible implications for the short-term adjustment to a fiscal devaluation, which makes this assumption uncritical for the exercise at hand.

We set the elasticity of substitution between goods produced in the same region ϵ to 9, implying a steady state price markup of 12.5 percent. Our chosen value is in the middle of the 6 to 11 range typically used in the literature. In addition, this value is often used in the New Keynesian literature, such as by Galí (2011), for example.

3.3. PARAMETER VALUES

Parameter	Value	Description
β	0.99	Discount factor
$1 - n$	0.34	Relative size of the South
ϕ	1	Labor supply parameter
ϵ	9	Elasticity of substitution between goods within regions
σ	2	Cross-country substitutability
ω	0.33	Share of imported goods in the South's consumption basket
ω^*	0.17	Share of imported goods in the North's consumption basket
τ^{VAT}, τ^{*VAT}	0.16	VAT rate
τ^{SCR}, τ^{*SCR}	0.24	SCR rate
α_π	1.5	Coefficient in the monetary policy rule
ρ^R	0.95	Interest rate smoothing
ψ	0.000001	Risk premium
ϵ_w	9	Elasticity of substitution between different types of labor
θ_p	0.66	Degree of price stickiness
θ_w	0.75	Degree of wage stickiness
ρ^{VAT}, ρ^{SCR}	0.999999	Persistence of tax shocks

Table 3.1: Parameterization of the model

In the business cycle literature, a wide range of values for the elasticity of substitution between different types of labor (ϵ_w) has been used. For example, Adolfson et al. (2007) use the value 21 in a model calibrated for the euro area, Kormilitsina & Nekipelov (2012) use 6 and Coenen et al. (2007) use 3. We set the parameter to 9, which is near the middle of the range used in the literature. This parameterization implies that the elasticity of substitution between different types of labor is equal to the elasticity of substitution between goods produced in the same region.

Cross-country substitutability, the elasticity of substitution between the South's and the North's goods (σ), is a key parameter, because it affects the strength of the expenditure-switching effect. The empirical literature shows a wide range of estimates for it. Feenstra et al. (2014) find that the micro elasticity (substitution between different import suppliers) between domestic and foreign goods is 3, whereas the macro elasticity (substitution between domestic production and imports) does not significantly differ from unity. We set cross-country substitutability to 2, which is an average of these estimates.

The share of imported goods in the South's consumption basket, ω , is set to match these countries' GDP-weighted import-to-GDP ratios. Our calculation, using the World Bank data (WorldBank, 2013), shows that the ratio is 33 percent, so ω is set to 0.33. We assume that the per-capita levels of output and consumption are identical across regions. This requires that $\omega^* = \omega(1 - n/n)$ so that the implied share of imported goods in the North consumption basket (ω^*) is 17 percent.

Kemmerling (2009) calculates effective social contribution and VAT tax rates for euro area countries (excluding Luxembourg). Our calculation shows that the GDP-weighted average for the VAT (SCR) rate in the euro area (excluding Luxembourg) is 16 percent (24 percent). We, therefore, set the VAT rate to 16 percent and the SCR rate to 24 percent. In comparison, Lipinska & Von Thadden (2012) set the VAT rate to 15 percent, based on nominal consumption tax rates in the euro area.

Wage and price rigidities are key variables in determining the adjustment of the two economies to a fiscal devaluation. Druant et al. (2009) analyze wage and price adjustment in ten euro-area countries and find that the average duration of wages (excluding Italy) is roughly one year. We match this figure by setting the Calvo parameter for wages (θ_w) to 0.75. Druant et al. (2009) find that prices are adjusted more frequently than wages. In ten euro-area countries the average duration of prices is 9.6 months. We set the Calvo parameter for prices (θ_p) to 0.66, which implies an average duration between price adjustments of

nine months.

Parameters (ρ^{VAT} , ρ^{SCR}) that govern the persistence of the South's tax shocks are set to 0.999999 (the North keeps their tax rates unchanged). This implies that tax shocks are virtually permanent.⁵ We consider a revenue-neutral shift from social contributions towards the VAT. The sizes of one-off tax shocks (ε_t^{VAT} , ε_t^{SCR}) in the South are set such that the VAT revenue is increased by 1 percent of ex-post GDP, while social contribution revenue is reduced by 1 percent of ex-post GDP.

3.4 International effects of a fiscal devaluation in the South

In this section, we analyze the international transmission of a fiscal devaluation in the South. We model a fiscal devaluation as a shift from social contributions to VAT equivalent of 1 percent of ex-post GDP. Our parameterization implies that, in order to achieve a shift of this magnitude, the VAT rate needs to be increased by 1 percentage point, whereas the SCR needs to be reduced by 1.7 percentage points. We solve the model by using a perturbation method based on a second-order accurate approximation of the system of equations. After showing the effects of a fiscal devaluation we go into more detail to shed light on the precise mechanisms at play (Section 4.1) and then do sensitivity analyses (Section 4.2).

The response of the main macroeconomic variables to a fiscal devaluation is shown in Figure 3.3 below. In all figures, the horizontal axis denotes time. The vertical axis typically shows percentage deviations from the initial steady state. However, the change in bond holdings, whose initial steady state is zero, is expressed as a deviation from initial GDP. In addition, the responses of inflation and interest rates are expressed as basis point deviations in annual terms.

Figure 3.3 emphasizes that a reduction in the SCR in the South implies a fiscal devaluation, which on impact lowers the relative price of the South's goods (a terms of trade deterioration for the South). The channel through which this terms-of-trade deterioration comes about is that the reduction in SCR lowers marginal costs for the South's firms, thus reducing producer prices.

The other component of the fiscal reform, the increase in the VAT rate in the South, pushes consumer prices up, mitigating the reduction in producer prices. However, the VAT increases the consumer price of the North's goods as well as of those of the South, while the reduction in SCR only reduces the South's prices. This mechanism is the essence of a fiscal devaluation, and results in lower relative prices of the South's goods, which, under a fixed nominal exchange rate, is equivalent to a real exchange rate devaluation.

The large increase in the South's output in the short term is demand driven. The terms of trade deterioration and the corresponding real exchange rate depreciation for the South causes the traditional expenditure-switching effect of an exchange rate change, a shift of euro area demand away from the more expensive North's goods and towards the cheaper South's goods. This expenditure-switching effect increases the South's output (employment) and decreases the North's output (employment) in the short term.

Due to the Calvo-pricing mechanism at work in the model, however, only a fraction of firms can lower prices on impact following the SCR reduction. After a few quarters, however, a larger fraction of the South's firms become able to lower their prices. This implies that the expenditure-switching effect becomes even stronger after a few quarters, pushing the South's output further up. As Figure 3.3 shows, a fiscal devaluation increases the South's level of output by 0.8 percent in the first quarter, while the peak impact is 1.2 percent in the fourth quarter.

However, the positive effect of a fiscal devaluation on the South's output through the expenditure-switching effect is mitigated by the wage-price dynamics. Immediately after a fiscal devaluation, wages start to adjust upwards in the South. This happens because the increase in consumption prices, caused by

⁵ To check the validity of this approach, we compared the convergent impulse responses with the steady state that would result from the new tax rates.

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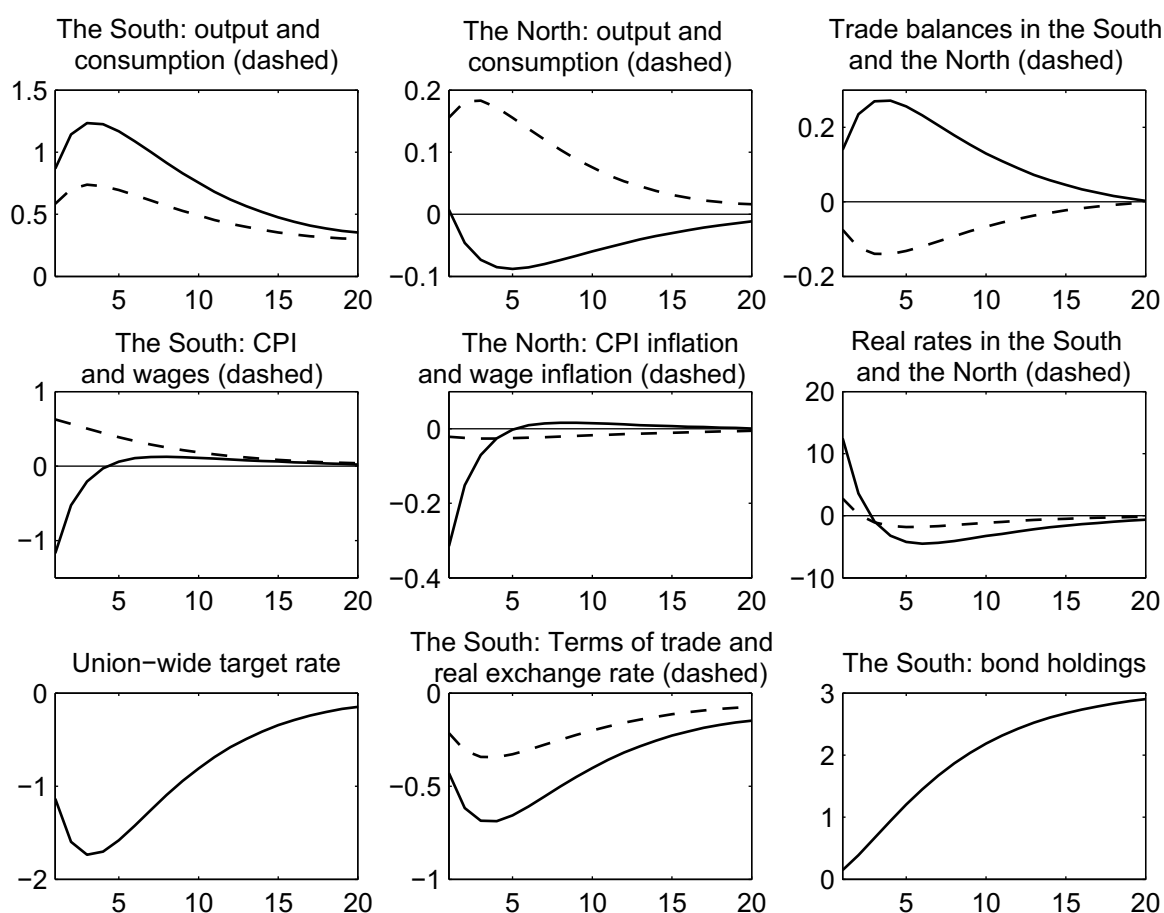


Figure 3.3: Dynamic effects of a fiscal devaluation.

Inflation and interest rates are expressed in annualized percentage points and basis point deviations, respectively. Deviations of trade balances are expressed in percentage of the initial GDP. For all other variables we report percentage deviations from their steady state values.

the increase in the VAT rate, pushes labor unions to require higher nominal wages. As a consequence, real marginal costs in the South, which had fallen on impact due to the reduction in the SCR rate, start to adjust toward the original, pre-reform level. This has a negative effect on output in the South, which gradually offsets the positive impact of the expenditure-switching effect discussed above. As a consequence of the various effects, output in the South displays a hump shaped response to a fiscal devaluation in these countries, and the tax reform still has a small positive effect on output, even in the long term.

Looking at the international transmission effects of fiscal devaluations, Figure 3.3 shows that the North's output decreases immediately after the reform. This result is due to the expenditure-switching effect, as discussed earlier. The peak effect (the most negative effect) on the North's output is -0.09 percent in the fifth quarter after a fiscal devaluation. After that, as inflation in the South and the real exchange rate stabilize, the expenditure-switching effect peters out, and output in the North slowly adjusts back to its pre-shock level.

In terms of effects on the external position, Figure 3.3 shows that in the South both output and consumption increase following a fiscal devaluation. However, the increase in consumption is smaller than that of output, due to the deterioration in the terms of trade of the South. As a consequence, households save a fraction of their increased income, leading to an improvement in the trade balance by about 0.27 percent of GDP, and to an accumulation of net foreign assets by the South, which at its peak amounts to slightly more than 3 percent of GDP.

However, the small risk premium in the interest rate parity equation forces bond holdings of the South to slowly revert towards their initial level in the long term. In the medium term, households in the South start using their accumulated wealth to finance consumption. As a consequence, the South's trade balance turns negative twenty quarters after a fiscal devaluation, and bond holdings of the South start declining, slowly reverting back to their pre-shock level. But note that since these are medium-term dynamics, the risk premium has no effect on the short-term adjustment and therefore does not inhibit the effects of a fiscal devaluation. Our results suggest that a fiscal devaluation could be used as a part of a policy package aimed at increasing output in the South and balancing the euro area economy. In particular, Figure 3.3 shows that the positive impact on the output and consumption of the South is larger than the negative impact on output and consumption of the North. In addition, the former is permanent, in the sense that even in the long term a small positive effect persists, whereas the latter is temporary, since the North's output and consumption revert back to their initial levels.

Our results therefore lend some support to the argument—made, for example, by IMF (2011)—that fiscal devaluations should not be seen primarily as a form of tax competition, but that they might entail a structural improvement. Arnold et al. (2011) have stressed that the shift from labor taxes to consumption taxes can increase the level of GDP in the long term, because consumption taxes are less distortive taxes in terms of discouraging work, compared to labor taxes. From this point of view, a fiscal devaluation carried out in a monetary union entails benefits for the countries who implement it (by making their goods more competitive) but also for the union as a whole, by shifting the tax system in the union towards a less distortive one.

Our results however suggest that a fiscal devaluation is not an effective means for addressing the divergence in competitiveness and the current account imbalance between the North and the South. In our model, a fiscal devaluation of roughly 4 percent of GDP is needed to correct—temporarily—the 1 percent trade balance deficit in the South. A fiscal devaluation of 4 percent of GDP implies that the VAT rate needs to be increased by 4 percentage points. VAT rates are already quite high in the South (see e.g. de Mooij and Keen 2013) and it may be difficult to raise them by such a large amount quickly. In addition, a fiscal devaluation of this size depreciates the real exchange rate of the South only by 1.2 percent. Overall, our findings indicate that it might be misleading to suggest that significant gains in competitiveness and net trade can be expected through a fiscal devaluation.

De Mooij & Keen (2012) emphasize that there is almost no empirical evidence on trade impacts of tax reforms or fiscal devaluations. Franco (2011) analyzes the effects of changes of value added taxes and

3.4. INTERNATIONAL EFFECTS OF A FISCAL DEVALUATION IN THE SOUTH

social contribution rates on real exports and imports in Portugal using a VAR methodology. His findings support both the feasibility and the effectiveness of fiscal devaluations.⁶ In particular, he finds that a positive one standard deviation VAT shock decreases real imports by 3.4 percent, while a negative one standard deviation SCR shock increases real exports by 4.4 percent.

De Mooij & Keen (2012) carry out a similar analysis using a panel of OECD countries. They find that, for euro area countries, a shift of 1 percent of GDP from social contributions to the VAT would increase net exports by about 0.9-4 percent of GDP, depending on the specification of the model. The estimate is smaller and statistically insignificant for countries outside the euro area. Their result, however, suggests that, within the euro area, whereas a fiscal devaluation might increase the trade balance quite sizably in the short term, the effects eventually disappear in the medium to long term. There seems to be a wide gap between our results (and all other theoretical results) and those of De Mooij & Keen (2012). Their empirical results, however, imply that raising the VAT rate by 1 percentage point and reducing the SCR by 1.7—the same policy that we calibrate in our model to achieve a 1 percent of GDP redistribution in taxation in the South—improves net exports by 0.4 percent of GDP.⁷ The results of our paper are broadly consistent with these empirical estimates regarding the effect on the trade balance. In our model, under the benchmark parameterization, the trade balance of the South improves by 0.27 percent of GDP, a somewhat weaker impact than the one found by de Mooij and Keen (2013). Consistent with the empirical evidence, we also find that the effect on the trade balance eventually disappears.

Farhi et al. (2014) use a new Keynesian two-country DSGE model to show that, even in the case of fixed exchange rates, fiscal policy can replicate the resource allocation attained under a nominal exchange rate devaluation. In particular, they find that two kinds of fiscal policy reforms can be equivalent to an exchange rate devaluation: a uniform increase in import tariff and export subsidy, and a VAT increase and a uniform SCR reduction. However, they do not use their two-country framework to analyze quantitatively the international transmission of a fiscal devaluation and the role of sticky prices in the transmission, as we do.⁸

Most previous papers have looked at these issues using small open economy models. A study by the Bank of Portugal (BOP, 2011) looks at the impact of a balanced-budget tax policy reform aimed at increasing the external competitiveness, using a small open economy model calibrated to the Portuguese economy. The reform consists of a 1 percent of GDP reduction in social contributions offset by an increase in consumption taxes. The result shows that a fiscal devaluation brings about a permanent real exchange rate depreciation of about 0.3 percent, which results in a permanent increase in output of about 0.6 percent, with the current account increasing on impact by 0.6 percent.

The European Central Bank (ECB, 2012) uses three different multi-country models—the National Institute Global Econometric Model (NiGEM), the New Multi-Country Model (NMcM) and the Euro Area and Global Economy (EAGLE) model—to analyze the effects of a fiscal devaluation in an individual country of the euro area, which can be considered a small open economy compared to the rest of the union. Their study finds that a fiscal devaluation—defined as an ex ante revenue-neutral 1 percent of GDP cut in social contributions offset by a rise in VAT over five years—implies a hump-shaped response in output, with almost no effect on impact but a peak effect in the range of 0.2-0.5 percent after 6-9 quarters. The effect on the current account is also negligible on impact, and the peak effect is in the 0.1-0.5 range. We find a much stronger effect on output in the short term, whereas the trade impact is in the range of the findings of the ECB.

Our result, that a fiscal devaluation is effective in terms of stimulating domestic output, is in contrast with that of Lipinska & Von Thadden (2012). As mentioned in the introduction, Lipinska & Von Thadden

⁶ Ivanova (2012), on the other hand, finds that reducing taxes on labor may actually worsen the current account balance.

⁷ De Mooij and Keen's (2013) estimates, using statutory tax rates, show that a 1 percentage point increase of the VAT rate (SCR) increases (reduces) net exports by 0.23 (0.11) percent. These estimates imply that raising the VAT rate by 1 percentage points and reducing the SCR by 1.7 percentage points improves net exports by $(-0.11 \times -1.7) + (0.23 \times 1) = 0.417$ percent of GDP.

⁸ Farhi et al. (2014) numerically evaluate the effects of a fiscal devaluation on a small open economy, calibrated to match the features of Spain.

(2012) analyze fiscal devaluation using a New Keynesian two-country model of a monetary union. Their model, therefore, is most directly related to ours. They find that the effectiveness of a fiscal devaluation depends on the degree of financial integration between the two countries. They, however, find that in a region whose size is half of a monetary union, fiscal devaluations tend to be ineffective. The peak effect on domestic output is only 0.05-0.15 percent in their model, compared to 1.2 percent in our model. In addition, the spillover effect on foreign output is also very small. In the next section, we provide a detailed discussion of the differences between our results and theirs. It turns out that wage rigidity plays a crucial role in our model.

3.4.1 The role of wage rigidity and labor taxation

The difference between our results and those of Lipinska & Von Thadden (2012) can—to a large extent—be explained by different types of shocks. In their model, fiscal devaluation is a permanent increase in the VAT by 1 percentage point and the additional VAT revenues are used to reduce the *labor* income tax such that the home country's long-term level of real government debt stays unchanged.⁹ In order to compare this version of a fiscal devaluation with the version that reduces the SCR, we replicate their version of a fiscal devaluation in our model. To this aim, we introduce labor income taxes, so the budget constraint of the representative household is now

$$B_{t+1} + (1 + \tau_t^{VAT}) P_t C_t = R_{t-1} B_t + (1 - \tau_t^w) W_t N_t + \Pi_t + T_t,$$

where τ_t^w is the labor income tax. The comparison is conducted separately in a model with flexible wages and with sticky wages.

Model with flexible wages

Figure 3.4 shows the effects of the two types of fiscal devaluations under flexible wages. Lines without markers depict the adjustment to a fiscal devaluation that cuts the SCR (our main exercise), while marked lines depict the impact of a fiscal devaluation that cuts labor income taxes (as in Lipinska & Von Thadden, 2012). As can be seen in Figure 3.4, both policies lead to a permanent output expansion of about 0.25%. The adjustment of real variables is virtually independent from whether additional revenue from the VAT hike is used to reduce labor income taxes or the SCR. The reason is that the adjustment of prices is almost identical under both policies. This is due to the fact that the adjustment of nominal wages—marginal costs—is virtually identical. In both cases, real marginal costs remain almost constant.

If a fiscal devaluation comprises a cut in the SCR, it shifts the nominal tax burden from firms to consumers, who pay a higher VAT. However, under flexible wages, the rise in the VAT is instantaneously compensated by a rise in nominal wages, so that the marginal rate of substitution is not affected. The immediate rise in nominal wages elevates marginal costs such that the reduction in the SCR is offset. Hence, real marginal costs are virtually constant, so the reduction in prices and the resulting expenditure-switching effect are negligible. The observed 0.25% increase in output originates from a reduction in distortions, which arises because social contributions are more distortionary than consumption taxes because the VAT tax base is larger than the labor income and SCR tax base.

In the adjustment to a fiscal devaluation that cuts labor income taxes, real marginal costs are almost constant because nominal wages do not change significantly. This is because a devaluation does not affect the allocation of the nominal tax burden: The decline in purchasing power that results from the VAT hike

⁹ Another difference between Lipinska & Von Thadden (2012) and our approach is their assumption that governments balance their real budgets every period by adjusting labor tax rates every period. We, in contrast, assume that all government spending is for public transfers to households and that a fiscal devaluation is revenue neutral in the long term. In our model, public transfers in the South increase very mildly in the short term. This implies that our finding that a fiscal devaluation is effective in the short term does not come from lower distortionary taxes that are financed by lump sum taxes or debt in the short term.

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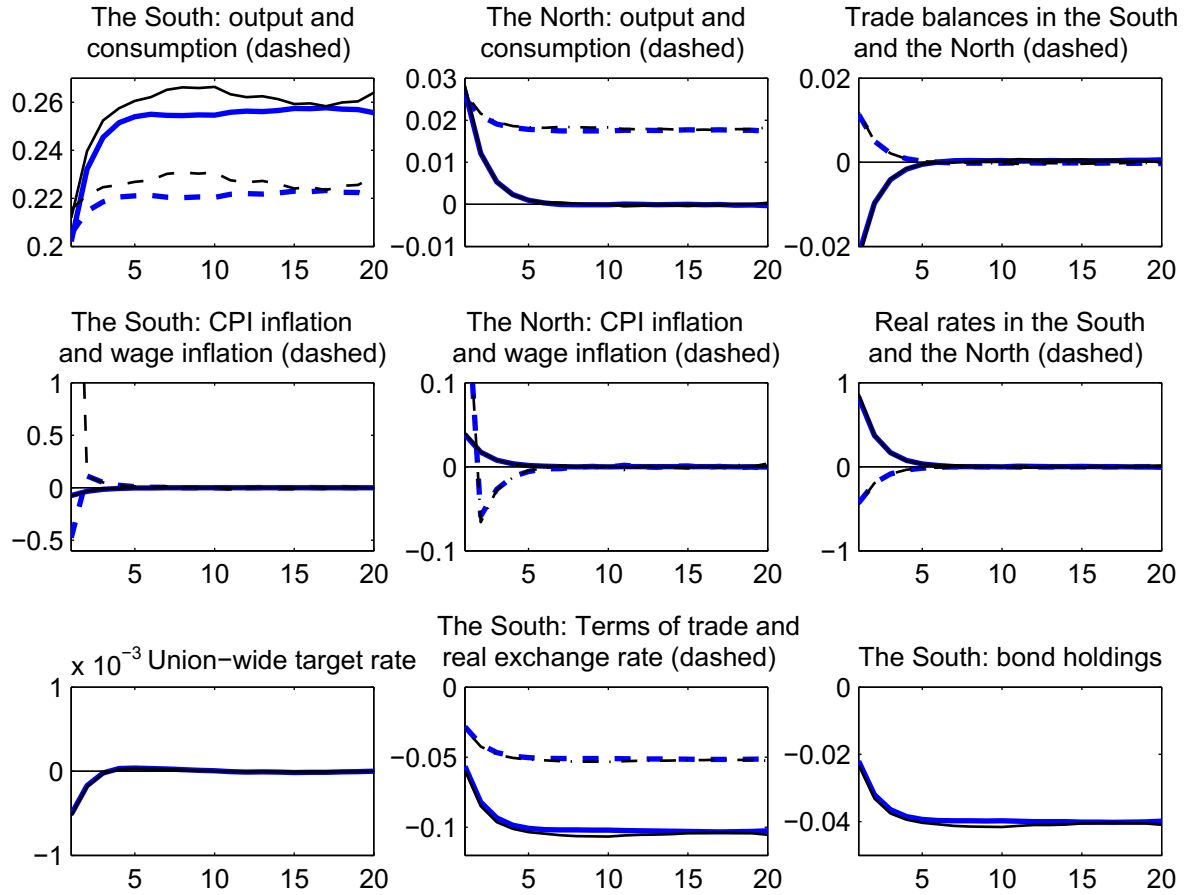


Figure 3.4: Comparing two types of fiscal devaluations under flexible wages.

Bold blue lines: Devaluation that cuts labor income taxes. **Black lines:** Devaluation that cuts the SCR. Inflation and interest rates are expressed in annualized percentage points and basis point deviations, respectively. Deviations of trade balances are expressed in percentage of the initial GDP. For all other variables we report percentage deviations from their steady state values.

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is compensated by the reduction in labor income taxes. As a result, nominal wages are not adjusted. The small but sustained impact on output is again explained by a reduction in distortions.

Model with sticky wages

Figure 3.5 contrasts the impact of the two types of fiscal devaluations in a model with sticky wages. A fiscal devaluation that cuts labor income taxes has roughly the same impact as in the model with flexible wages. In contrast, and as shown in Section 4, the adjustment to a fiscal devaluation that cuts the SCR is dramatically stronger: Output peaks at about 1.2% above its steady-state value, so the impact is at its maximum roughly 5 times as large as for the other type of devaluation.

In this version, nominal wages do not immediately adjust when after-tax real wages deviate from their long-term value, i.e. from a markup over the present value of marginal rates of substitution. In particular, when after-tax real wages deviate from their long-term value, labor unions only gradually adjust wages to re-establish the initial markup. This is not consequential for a devaluation that cuts labor income taxes: As explained above, there is no shift of the nominal tax burden and after-tax real wages remain virtually unchanged, because the labor tax reduction is almost completely offset by the VAT increase. Labor unions, therefore, do not want to change wages anyway. This explains why price stickiness is not crucial for the impact of this type of fiscal devaluation. However, price stickiness matters dramatically for devaluations that cut the SCR. Here, a devaluation shifts the nominal tax burden from firms towards workers and reduces after-tax real wages (due to the VAT hike). While the reduction in purchasing power of workers immediately increases wages in the model without wage rigidity, it only generates willingness of labor unions to increase wages in the model with rigidity, but only limited action. This means that there is no immediate increase in wages, so marginal costs decline on impact by the full amount of the SCR reduction. The VAT hike only gradually feeds into higher wages as more labor unions are allowed to re-adjust wages. Hence, in the composition of marginal costs, the decline in the SCR is only gradually offset by rising wages. As a result, the price decline is dramatically stronger than under a devaluation that cuts labor income taxes. This in turn implies a stronger real devaluation and a more pronounced expenditure-switching effect towards domestic goods.

As further discussed in Section 4.2, some of the differences in results between Lipinska & Von Thadden (2012) and ours can be explained by the use of different parameter values.¹⁰ For example, we set cross-country substitutability to 2, whereas Lipinska & Von Thadden (2012) set it to 1.5. A higher cross-country substitutability implies that the expenditure-switching effect, which increases the South's output and decreases the North's output in the short term, is higher in our model. However, the above discussion shows that the major difference is the different tax rate on labor employed.

¹⁰ In addition, part of the difference in results between our results and those of Lipinska & Von Thadden (2012) can be explained by different solution methods. Lipinska & Von Thadden (2012) use a first-order approximation, which ignores the cross term, i.e. the change in the tax-base times the change in the tax rate. The use of the second-order approximation, in our model, increases the effect of fiscal devaluation on South's output in the short term by 10 percent.

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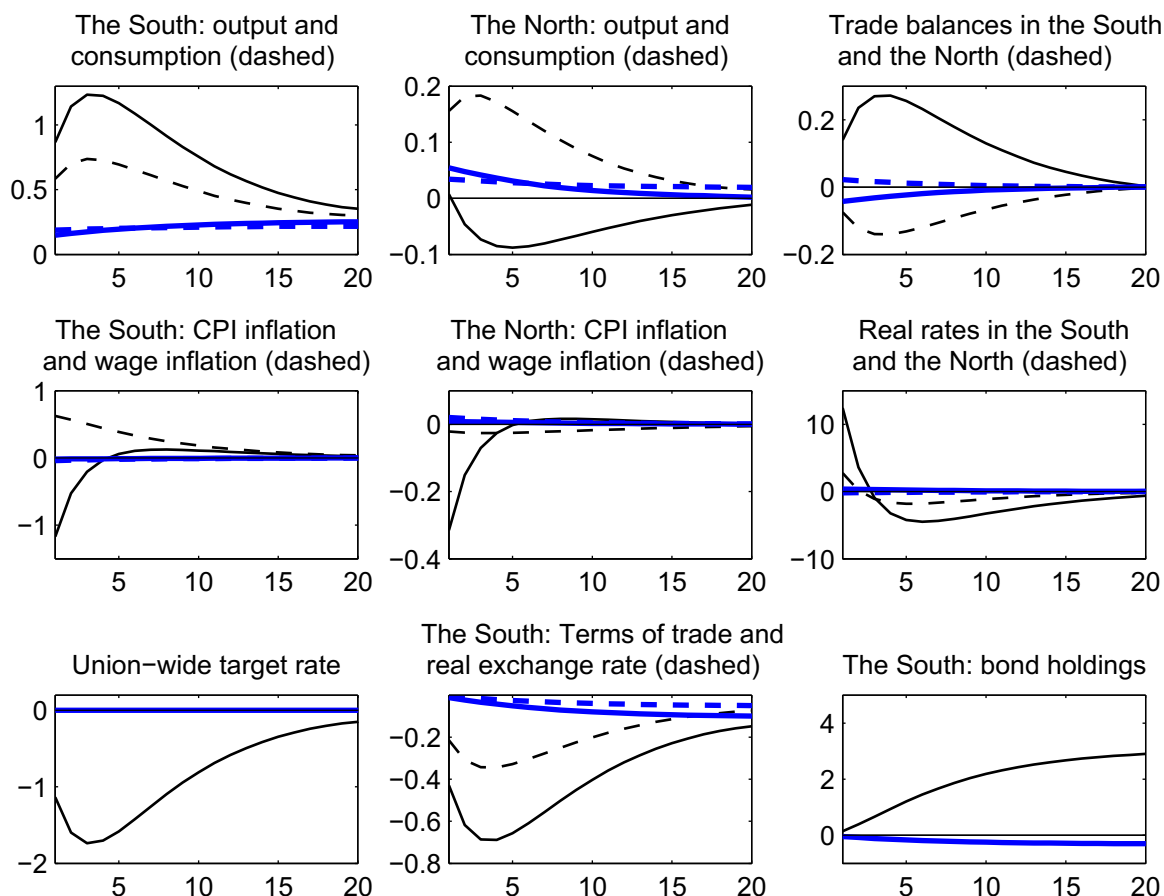


Figure 3.5: Comparing two types of fiscal devaluations under sticky wages.

Bold blue lines: Devaluation that cuts labor income taxes. **Plain lines:** Devaluation that cuts the SCR. Inflation and interest rates are expressed in annualized percentage points and basis point deviations, respectively. Deviations of trade balances are expressed in percentage of the initial GDP. For all other variables we report percentage deviations from their steady state values.

3.4.2 Sensitivity analysis

In this section, we analyze how sensitive the effects of a fiscal devaluation on the main variables are to changes in key parameter values. Figure 3.6 and Table 3.2 show the consequences of varying key parameter values.

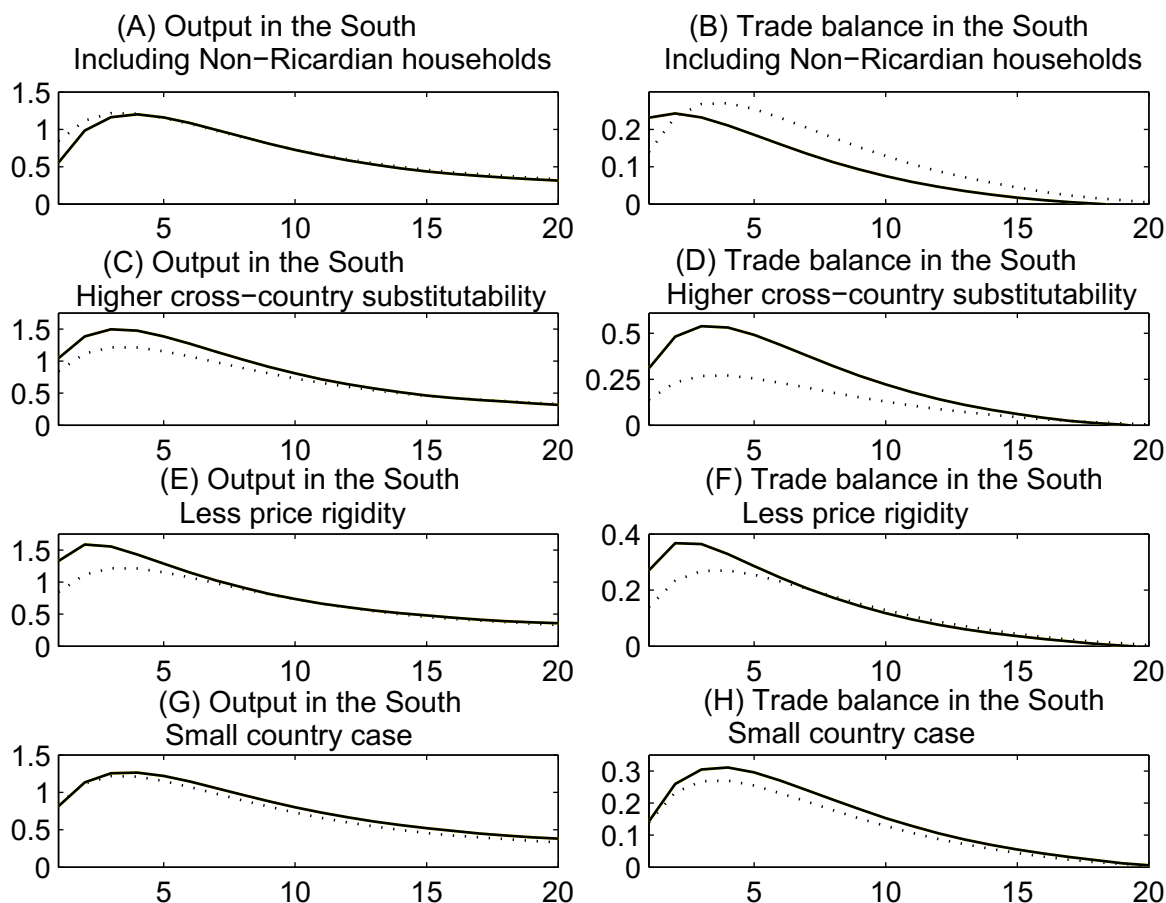


Figure 3.6: Effects of varying key parameter values.

Solid lines: Adjustment under respective model variation. **Dotted lines:** Adjustment in the benchmark model (for comparison).

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Row	Parameters/Specification	Peak effect on the South's output	Peak effect on the North's output	Peak effect on the South's trade balance	Peak effect on the North's trade balance
1	Benchmark	+ 1.21%	-0.08%	+0.27%	-0.14%
2	$\lambda = \lambda^* = 0.5$	+1.2%	-0.13%	+0.24%	-0.12%
3	$\sigma = 3$	+1.49%	-0.21%	+0.53%	-0.27%
4	$\sigma = 1.5$	+1.03%	-0.03%	+0.13%	-0.06%
5	$\theta_p = 0.5$	+1.58%	-0.12%	+0.36%	-0.19%
6	$1 - n = 0.05$	+1.26%	-0.01%	+0.31%	-0.01%
7	$\omega = 0.25$	+1.17%	-0.07%	+0.22%	-0.11%
8	$\phi = 2.5$	+1.36%	-0.11%	+0.33%	-0.17%
9	$\theta_w = 0.8, \theta_w^* = 0.75$	+1.36%	-0.09%	+0.3%	-0.15%
10	Different tax pass-through	+0.80%	-0.26%	+0.63%	-0.14%

Table 3.2: Consequences of varying key parameter values.

Columns 3 and 4 show deviations of output as a share of pre-devaluation output, and columns 5 and 6 show absolute deviations of the trade balance as a share of current GDP.

Non-Ricardian households: In a first sensitivity analysis, we follow Galí et al. (2007) and assume that only a fraction $1 - \lambda$ of households are *Ricardian* (denoted now by superscript R) while a fraction λ of households are *non-Ricardian* (denoted by superscript N) who do not optimize utility intertemporally; they consume their current labor income in each period and they do not own assets nor have liabilities (Ricardian households own firms). The inclusion of non-Ricardian households is justified by several empirical studies. Campbell & Mankiw (1990), for example, find that aggregate consumption can be explained by both permanent and current income. Mian & Sufi (2010) find that credit constraints can explain a large fraction of consumption in a recession. In addition, the euro area suffers from a banking crisis, which harms financial intermediation.

Non-Ricardian households do not intertemporally optimize their behavior. Instead they maximize on a period-by-period basis the utility function

$$U_t^N = \left\{ \log C_t^N - \frac{(N_t^N)^{1+\phi}}{1+\phi} \right\} .$$

where the consumption index is identical to the basic case. Their budget constraint is given by

$$(1 + \tau_t^{VAT}) P_t C_t^N = W_t N_t^N + T_t .$$

and their level of consumption is

$$C_t^N = \frac{W_t N_t^N}{(1 + \tau_t^{VAT}) P_t} + \frac{T_t}{(1 + \tau_t^{VAT}) P_t} .$$

The South's aggregate consumption is $C_t = \lambda C_t^N + (1 - \lambda) C_t^R$.

We assume that Ricardian and non-Ricardian households do not differ with respect to their labor market characteristics. We assume that the marginal rate of substitution that unions take into account is a weighted average of both households' marginal rates of substitution between consumption and leisure. Although households can have different levels of consumption, both types work the same number of

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hours.¹¹ Therefore, the labor union z 's objective is given by

$$\max_{W_t(z)} \sum_{k=0}^{\infty} \beta^k \theta_w^k \mathbb{E}_t \left\{ \left(\frac{1-\lambda}{C_{t+k}^R} + \frac{\lambda}{C_{t+k}^N} \right) \frac{W_t(z)}{(1+\tau_t^{VAT}) P_{t+k}} N_{t+k|t}(z) - \frac{N_{t+k|t}^{1+\phi}(z)}{1+\phi} \right\},$$

and the first-order condition is

$$\sum_{k=0}^{\infty} \beta^k \theta_w^k \mathbb{E}_t \left\{ N(z)_{t+k|t} \left(\left(\frac{1-\lambda}{C_{t+k}^{RH}} + \frac{\lambda}{C_{t+k}^{NR}} \right) \frac{W_t^O}{(1+\tau_t^{VAT}) P_{t+k}} - \frac{\epsilon_w}{\epsilon_w - 1} (N(z)_{t+k|t})^\phi \right) \right\} = 0$$

Figure 3.6(a) and rows 1 and 2 of Table 3.2 show that the effect of a fiscal devaluation on output is only slightly stronger in the short term, when one half of households is non-Ricardian ($\lambda=\lambda^*=0.5$). Non-Ricardian households consume their current labor income in each period. The rise in nominal wages, the fall of prices and the increase in employment (see Figure 3.3) that last for several quarters dominate the income reducing effect of the increase in the VAT. Non-Ricardian households' real income and consumption increase for five quarters after the change in taxes. The initial increase in consumption, however, is relatively muted when compared with the Ricardian households, as Figure 3.3 illustrates. The reason is that the increase in income evolves slowly due to the staggering price and wage changes. A conclusion is that the *short-term* effectiveness of a fiscal devaluation is slightly weakened by the presence of non-Ricardian households when prices and wages need time to adjust. Our finding is consistent with Boscá et al. (2012) who find that when the share of non-Ricardian consumers gets larger, the output effect of a fiscal devaluation becomes weaker.

Cross-country substitutability: Empirical estimates on cross-country substitutability vary and the international economics literature uses a wide range of parameter values for it. Row 3 of Table 3.2 and Figure 3.6(c) show that the higher cross-country substitutability, the higher the output and trade balance effect of a fiscal devaluation. The fact that the South's and the North's goods are now better substitutes implies that the expenditure-switching effect is stronger. This increases the South's output and decreases the North's, when compared with the benchmark case. A higher increase in the South's output means that their households have more extra income in the short term. Consequently, the accumulation of international assets becomes stronger and the effect of a fiscal devaluation on the trade balance increases strongly.

The earlier literature has found that the output effects of a fiscal devaluation are robust to changes in the value of cross-country substitutability. European Commission (Commission, 2006) finds that raising it from 2 to 5 increases the effect of a fiscal devaluation, in which labor income taxation is cut, on long-term output only from 0.2 to 0.24 in Germany. However, cross-country substitutability—most of all—governs the strength of the expenditure-switching effect in the short term. The long-term focus is therefore somewhat misleading. Boscá et al. (2012), however, find that even short-term output effects are robust to values of cross-country substitutability. They show that doubling cross-country substitutability has virtually no impact on accumulated GDP after two years in Spain. In this paper, we show that the effects of a fiscal devaluation on output are more sensitive to the value of cross-country substitutability than the earlier literature has found.

Row 4 of Table 3.3 shows the effects of a fiscal devaluation in a case where cross-country substitutability is set to 1.5, as in Lipinska & Von Thadden (2012). A low cross-country substitutability implies a weaker expenditure-switching effect. Therefore, the increase in the South's output becomes weaker. We, however, still find a much stronger effect on output than Lipinska & Von Thadden (2012).

The European Commission (CPB, 2013) finds that the trade balance effects of a fiscal devaluation are robust to values to cross-country substitutability. Doubling cross-country substitutability has a minor

¹¹Drautzburg & Uhlig (2015) use a similar approach.

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quantitative impact on the trade balance. In our model, however, doubling cross-country substitutability from 1.5 to 3 increases the peak effect of a fiscal devaluation on the South's trade balance by 44 percent. We can therefore conclude that the effect of a fiscal devaluation on the trade balance is much more sensitive to the value of cross-country substitutability than the earlier literature has found.

Price rigidity: Figures 3.6(e) and 3.4 and row 5 of Table 3.2 show the consequences of varying the degree of price rigidity. In an alternative setup, we set the price rigidity parameter to 0.5, implying an average delay of six months between price adjustments. This is consistent with the estimates of Bils & Klenow (2004). In this case, prices are more flexible. In the short term, a larger fraction of firms has an opportunity to lower prices and take the cost advantage of a reduction of the SCR rate. In the short term, a fiscal devaluation lowers the relative price of the South's goods by more than under the benchmark parameterization. Therefore, a stronger expenditure-switching effect explains a stronger increase of the South's output in the short term. The policy implication of this is that goods market reforms that foster price flexibility render fiscal devaluations more effective. On the other hand, as prices are more flexible, the expenditure-switching effect fades away faster than under the benchmark parameterization.

Country size: The next step is to investigate the role of the country size. The European Commission (CPB, 2013) argues that improving the competitiveness by a fiscal devaluation in one country happens at the expense of the competitiveness of another country. The beneficial effects on the trade balance get smaller if a fiscal devaluation is carried out in several countries at the same time. We analyze the small-country case by setting the relative size of the country that carries out fiscal devaluation to 5 percent ($1 - n = 0.05$). The assumption that the per-capita level of output and consumption is identical across regions implies that the share of imported goods in the rest of the euro area must be changed to 1.7 ($\omega^* = 0.017$).

Figures 3.6(g), 3.6(h) and row 6 of Table 3.2 show that a fiscal devaluation carried out in a small country increases the domestic output by more than in the benchmark case. This finding is consistent with that of CPB (2013). CPB (2013) finds that the unilateral implementation of a fiscal devaluation is the best option for a country that wants to expand its GDP. The output effects become less favorable when several countries implement fiscal devaluations in a coordinated way.

Openness: Next, we analyze the role of the degree of openness. As discussed in section 3, we set the share of imported goods in the 'Southern European countries' consumption basket to match the empirically observed import-to-GDP ratio. In comparison, Lipinska & Von Thadden (2012) set the share of imported goods to 25 percent in both countries (that are of equal size). In an alternative scenario, we set $\omega = 0.25$ which implies that the share of imported goods in the North's consumption basket (ω^*) must be changed to 0.13 percent. Lipinska & Von Thadden (2012) show that the introduction of home bias slightly dampens the effect of a fiscal devaluation on output in the long term. Row 7 of Table 3.2 shows that our findings complement their findings. In a more closed economy the expenditure-switching effect is smaller and consequently the effect of a fiscal devaluation becomes weaker in the short term.

Labor supply elasticity: A potentially important parameter is the Frisch elasticity of labor supply. Lipinska & Von Thadden (2012) set it to 0.4, whereas we set it to one in our benchmark parameterization. In an alternative scenario, we set $\phi = 2.5$. This implies that the Frisch elasticity, which is $1/\phi$ in our model, is 0.4. Row 8 of Table 3.2 shows that the lower the Frisch elasticity, the weaker the output effect of a fiscal devaluation. However, also in the alternative scenario we find a much stronger output effect than Lipinska & Von Thadden (2012).

Labor market asymmetries across regions: ? find that the average duration of wages is roughly four quarters in the North (now Austria, Belgium, France and the Netherlands) and roughly five in the South. For this reason, we analyze the consequences of labor market asymmetries across regions by setting the Calvo parameter for wages in the South to 0.8, implying an average delay of five quarters between wage adjustments and keep the value at 0.75 for the North as in the benchmark calibration. Row 9 of Table 3.2 shows that this makes the output effect of a fiscal devaluation stronger. The reason for this finding is that the bigger degree of wage rigidity in the South further dampens the effect of the VAT rate increase

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on wages allowing a bigger fall in marginal costs and thus a stronger fiscal devaluation.

Tax pass-through: In our baseline specification, we assumed that firms' price setting is exclusive of the VAT in the sense that consumers pay the VAT, while firms are only indirectly affected through its effect on aggregate demand for goods and on wage setting. Moreover, it implies that pass-through of the VAT on consumer prices is complete in the first period. We next present a slightly different set-up where firms pay the VAT when goods are sold domestically, while consumers continue to pay it on imports. Thereby the price setting decision is directly affected by the VAT of the firms' respective home economies, while they do not consider the respective foreign VAT which is paid on exports by foreign consumers.

This modification affects the profit function and thereby the price setting equation of firms and the household's budget constraint. Southern firm i 's profit function now reads

$$\Pi_t(i) = (1 - \tau_t^{VAT}) P_t^S(i) Y_t^{SS}(i) + P_t^S(i) Y_t^{SN}(i) - (1 + \tau_t^{SCR}) s w_t W_t N_t(i)$$

where $Y_t^{SS}(i)$ and $Y_t^{SN}(i)$ are the firm's domestic and foreign sales, respectively. Because now the firm pays the domestic VAT, the price it charges implicitly takes account of it.

The budget constraint of the South's household is

$$B_{t+1} + P_t^S C_t^S + (1 + \tau_t^{VAT}) P_t^N C_t^N = R_{t-1} B_t + W_t N_t + \Pi_t + T_t \quad .$$

The last line of Table 3.2 shows the effects of a fiscal devaluation. The peak output effect is about 0.8% and smaller than in the benchmark case. This is the result of two effects working in opposite directions. First, the inclusion of the South's VAT in the firms' price setting equations tends to increase the optimal price after the shock because firms' profits from sales in the South fall when the VAT rises. This effect works directly against the price reducing effect of the SCR reduction. This effect is, however, muted because of the Calvo mechanism. Second, the increase in the South's VAT increases the price of imported goods from the North. This effect is not muted by the Calvo mechanism so that the relative price of the South's domestic goods falls strongly incurring expenditure switching by the South's consumers away from the North's goods to domestic goods. The latter effect is dominated by the first one, so that the peak effect is smaller. However, the output effect remains sizable. But note that the trade effect is significantly larger now implying that the second effect has a sizable impact on the terms of trade.

3.5 Conclusion

Correcting the loss of competitiveness in the South and the current account imbalance between the North and the South are challenging jobs for the euro area. We find that a fiscal devaluation in the South depreciates its real exchange rate and improves its trade balance. The advantageous short-term effects of a fiscal devaluation, however, should not be overemphasized: a fiscal devaluation, under the benchmark parameterization, depreciates the real exchange rate by 0.3 percent and improves the trade balance by 0.3 percent of GDP, which are quite small effects. Our findings therefore suggest that a fiscal devaluation alone would not be sufficient to correct the divergence in competitiveness and the current account imbalance between the South and the North of the euro area. A fiscal devaluation should however be part of a wider package of economic policy reforms aimed at increasing the competitiveness of the South, including product and labor market reforms and wage moderation, for instance.

In our model, a fiscal devaluation is much more effective in terms of stimulating domestic short-term output than earlier models have found. We found that—assuming sticky wages—a fiscal devaluation, of 1 percent of GDP, increases the level of output in the South by 0.8-1.6 percent, depending on the parameterization. Furthermore, a fiscal devaluation entails a structural improvement, because it has a positive effect on output in the long term. Our findings suggest that a fiscal devaluation could be used as a part of a policy package aimed at increasing output in the South.

THIRD ESSAY

The statutory breakdown of payroll taxes between firms and workers and the business cycle

According to conventional wisdom, the statutory split of payroll taxes between firms and workers is irrelevant for the real allocation in the long run, as tax incidence is fully determined by the market structure when prices and wages adjust. This paper breaks with this view, by showing that if payroll taxes are levied on workers, business cycle fluctuations of prices and wages are smaller than under the formal taxation of firms. Lower nominal volatility mitigates price and wage dispersion, and thereby the productivity loss from business cycles. In a standard DSGE model calibrated to a typical European country, a full shift of contributions from firms to workers reduces the welfare costs of the business cycle by 11.25%.

4.1 Introduction

It is well known that in a market setting with flexible prices, the breakdown of the burden of a transaction tax between buyer and seller is fully determined by the price elasticities of demand and supply. This insight, which goes back at least to Dalton (1922), is known as “liability side equivalence” or “tax incidence equivalence” and is a standard principle of public finance (see Stiglitz (2000), for example). In the context of the labor market, the principle implies that the liability side of a payroll tax – i.e., whether it is imposed on employers or employees – is irrelevant for the distribution of the tax burden.¹ The study at hand shows in a New Keynesian model that liability side equivalence holds in the long run, but that the liability side nevertheless matters for welfare costs of business cycle fluctuations. In a model calibrated to a representative European country, a full shift of payroll taxation from firms to workers reduces the welfare loss from business cycle fluctuations by 11.25%.

The otherwise standard DSGE model features a social security system that is funded by a payroll tax (social security contributions). The tax rate is assumed to be time variant because the government adjusts the rate in order to stabilize social security contributions over the cycle. When the tax base (gross total labor compensation) declines in a recession, the government *ceteris paribus* has to increase the tax rate to sustain constant revenues. Vice versa, a surging tax base during upswings has to be compensated by a tax rate reduction.² This assumption is also made by Burda & Weder (2016), who also provide empirical evidence. Cyclical adjustments in the tax rate contribute to price and wage volatility, because changes in the tax rate lead firms and labor unions to adjust prices and wages. In a Calvo-setup, nominal volatility gives rise to price and wage dispersion, which impedes an efficient allocation of resources and reduces the economy’s productive capacity. This productivity loss counts towards welfare costs of business cycles. Its emergence is summarized in Figure 4.1.

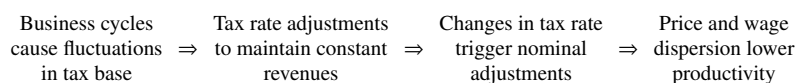


Figure 4.1: The role of the social security system in nominal volatility.

The paper shows that the liability side of social security contributions affects the size of tax rate adjustments that are necessary to stabilize revenues over the cycle. If contributions are levied on workers, stabilizing revenues requires smaller adjustments in the tax rate than in the case when contributions are levied on firms. In Figure 4.1, this corresponds to a weaker link from business cycles (first item) to tax rate adjustments (second item). As a result, given business cycle dynamics cause less volatility in the tax rate, which reduces the size of the productivity loss and thereby welfare costs. The intuition for this result

¹If a payroll tax is imposed on workers, it is a labor income tax that lowers the net wage for a given gross wage. Imposed on firms, payroll taxes scale up the effective wage bill for a given gross wage bill. In this paper, this distinction is made for the employer’s portion and the employee’s portion of social security contributions. Formally, firms pay the entire tax burden of both sides. However, because firms and workers usually negotiate over a gross wage that includes the worker contribution but excludes the firm contribution, the nominal tax burden is nevertheless split between both sides. Consider for example a German hourly minimum wage of 8.50€, and a contributions rate of 40% split equally between both sides. The firm pays a total of $8.50 \times 1.2 = 10.20$ € per hour, of which 3.40€ (2×1.70 €, the sum of the contributions of both sides) are paid to the government, and 6.80€ are paid to the worker. Since the worker contribution of 1.70€ is deducted from the paycheck and paid to the government on her or his behalf, while the wage agreed upon is 8.50€, the worker portion of contributions is economically a labor income tax.

²In reality, social security expenditures tend to move against the cycle, as e.g. unemployment insurance requires more funding in downturns than in expansions (see Dolls et al. (2012), for example). This puts further pressure on a government to adjust the tax rate in a counter cyclical manner. This observation is neglected in the baseline model for the sake of tractability. However, it is accounted for in a robustness check, and shown to quantitatively strengthen the results of the paper.

THIRD ESSAY ON LIABILITY-SIDE EQUIVALENCE

	Deterministic steady state	Impact of change in social security revenues
Tax levied on workers	After-tax wage: $(1 - \tau)W^{high}N$ After-tax profits: $Y - W^{high}N$	Increasing revenues by 1m € requires to adjust the tax rate by $\Delta\tau = 1m/(W^{high}N)$
	\Updownarrow Pre-tax values differ, but after-tax values identical because of LIE.	\Updownarrow Taxing workers: a smaller tax rate hike is needed to raise additional 1m euro.
Tax levied on firms	After-tax wage: $W^{low}N$ After-tax profits: $Y - (1 + \tau)W^{low}N$	Increasing revenues by 1m € requires to adjust the tax rate by $\Delta\tau = 1m/(W^{low}N)$

Figure 4.2: Link between liability side and tax rate volatility.

is summarized in Figure 4.2.³

The left column compares the deterministic steady state under both liability sides. Because liability side equivalence holds in the flexible-price allocation, the taxation of workers is compensated by higher pre-tax wages. That is, after-tax wages $(1 - \tau)W^{high}N$ are equal to their value under firm taxation, $W^{low}N$. Since the same holds for after-tax firm profits, the real allocation in the deterministic steady state is independent from the liability side. However, the fact that pre-tax wages are higher under worker taxation is crucial for the size of the tax rate adjustment required to change revenues by a given amount. The right column compares the size of tax rate adjustments required to increase revenues by an exemplary amount of one million euro, starting from the deterministic steady state. Since the required adjustment in the tax rate equals one million divided by the steady state tax base – i.e. gross labor compensation WN^4 – it is smaller under worker taxation, when the tax base is larger due to higher wages. This reasoning does not only apply for the example of increasing revenues, but also for tax rate adjustments aimed at stabilizing revenues in the face of fluctuations in the tax base. Intuitively, when revenues react stronger on tax rate changes (i.e. when the tax base is larger), a given deviation in the tax base can be compensated by a smaller tax rate adjustment. Hence, worker taxation implies a weaker transmission of business cycle fluctuations in the tax base to tax rate adjustments, which mitigates the productivity loss summarized in Figure 4.1.

Payroll taxation represents a large component of public finance in developed nations, especially in Europe. In 2013, the total of employee and employer social security contributions exceeded a third of total labor costs in eight OECD countries.⁵ These large figures result from a rapid growth of payroll tax rates that started in 1960 (see Gruber (1997), for example). In the vast majority of European OECD countries, social contributions are not primarily levied on workers (see Table 4.5 in the Appendix). In the light of the model, this suggests substantial scope to reduce business cycle costs.

There is a broad body of literature on liability side equivalence, with contributions from the fields of public finance, labor economics and behavioral economics. Mieszkowski (1967) provides a unified treatment of classic theoretical tax analysis. In labor economics, a strand of literature examines whether liability side equivalence holds in the presence of market imperfections, that is, in the context of efficiency-wage and wage-bargaining models (see, among others, Picard & Toulemonde (2001), Rasmussen (1998) or Koskela & Schöb (1999)). Regarding empirical work, Lehmann et al. (2011) and Gruber (1997) are recent studies on the principle's validity. Weber & Schram (2013) conduct a laboratory experiment to analyze the implications of the liability side of payroll taxation under bounded rationality. The paper at hand is also loosely related to the literature on automatic stabilizers (see Furceri (2010) for a recent

³In the figure, τ , N , W^{high} and W^{low} denote tax rate, hours worked and nominal wages under worker taxation and firm taxation respectively. LIE abbreviates liability side equivalence.

⁴The tax base is gross labor compensation, regardless of whether contributions are levied on workers or on firms.

⁵Austria, Belgium, the Czech Republic, France, Germany, Greece, Hungary and the Slovak Republic. See OECD Taxing Wages 2013.

overview), as the liability side in the model passively affects nominal volatility caused by business cycles.

Section 4.2 lays out the model and discusses the calibration. Section 4.3 analyzes the implications of the liability side for the adjustment to exogenous shocks, which explain the welfare results presented in section 4.4. Section 4.5 provides robustness checks. The paper concludes with section 4.6.

4.2 The model

In the closed-economy New Keynesian DSGE model, the economy is populated by a continuum of firms and a continuum of infinitely-lived households. Firms produce differentiated intermediate goods, which are aggregated into a final goods bundle consumed by households. Likewise, households supply differentiated types of labor, which enter the production function subject to aggregation into a composite of labor services. Since different intermediate goods and different labor types are imperfect substitutes, firms and workers have market power. Price and wage setting are staggered by Calvo mechanisms. A social security system is financed by payroll taxes and reimburses revenues as lump-sum transfers to households. Depending on the scenario, contributions are either levied on firms or on workers. A government consumes according to an exogenous process, with public consumption defined as plain waste. Its expenditures are fully financed by lump-sum taxes in every period. Monetary policy is governed by a standard Taylor rule. There are two sources of uncertainty in the economy: productivity shocks and demand shocks that affect government spending.

4.2.1 Households

The index $j \in [0, 1]$ for households is suppressed for ease of notation. While the consumption decision results from intertemporal optimization, hours worked are determined by labor demand as workers reduce their labor supply below the competitive level. Lifetime utility is given by:

$$U_t = \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \left(\frac{c_{t+k}^{1-\gamma}}{1-\gamma} - \frac{n_{t+k}^{1+\phi}}{1+\phi} \right),$$

where n_{t+k} and c_{t+k} are hours worked and consumption in period $t+k$. Maximization is subject to the series of period budget constraints for $t \geq 0$:

$$P_t c_t + (1/R_t) b_t \leq b_{t-1} + (1 - \tau_t^w) w_t \int_0^1 n_t(i) di + ssb_t - tax_t + \Pi_t, \quad (4.1)$$

where P_t is the economy's price index (defined below) and R_t is the gross nominal interest rate on a one-period risk-free nominal bond b_t maturing at the beginning of $t+1$. τ_t^w is the rate of employee's social security contributions, which are deducted from nominal labor income, given by $w_t \int_0^1 n_t(i) di$.⁶ Note that τ_t^w is zero in the scenario of taxing firms. The term ssb_t denotes lump-sum social security benefits, tax_t are lump-sum taxes levied by the government and Π_t denotes nominal profits from the ownership of firms. The resulting Euler equation is:

$$R_t = \beta \mathbb{E}_t \left(\frac{c_t}{c_{t+1}} \right)^\gamma \frac{P_t}{P_{t+1}}.$$

The Dixit-Stiglitz aggregate c_t consists of all varieties $c_t(i)$ produced by firms on the continuum $[0, 1]$. Aggregation is undertaken by a competitive final-goods firm using technology

$$c_t \equiv \left(\int_0^1 c_t(i)^{1-\frac{1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}. \quad (4.2)$$

⁶The household earns the same wage for its work at all different firms on the continuum, each indexed by i . One can think of household members being sent out to work at all firms on the continuum, and labor income being pooled at the end of the period.

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Cost-efficient composition of c_t implies the following household demand for the variation produced by firm i , where $p_t(i)$ denotes its price:

$$c_t(i) = \left(\frac{p_t(i)}{P_t} \right)^{-\epsilon} c_t \quad . \quad (4.3)$$

The economy's aggregate price index is defined as:

$$P_t \equiv \left(\int_0^1 p_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}} \quad . \quad (4.4)$$

4.2.2 Firms and price setting

Firm i produces its goods variation $y_t(i)$ with a linear production function:

$$y_t(i) = A_t n_t(i) \quad , \quad (4.5)$$

where productivity is governed by $\log A_t = \rho^A \log A_{t-1} + \epsilon_t^A$ with $\epsilon_t^A \sim N(0, \sigma^A)$ allowing for aggregate productivity shocks. The input is a labor composite $n_t(i)$ that contains differentiated labor variations $n_t(i, j)$ of all households j :

$$n_t(i) \equiv \left(\int_0^1 n_t(i, j)^{1-\frac{1}{\epsilon_w}} dj \right)^{\frac{\epsilon_w}{\epsilon_w-1}} \quad . \quad (4.6)$$

Analogous to (4.3), cost-minimizing composition of $n_t(i)$ implies the following demand schedule for type- j labor:

$$n_t(i, j) = \left(\frac{w_t(j)}{W_t} \right)^{-\epsilon_w} n_t(i) \quad , \quad (4.7)$$

where $w_t(j)$ is the wage for type- j labor and W_t is the aggregate wage index:

$$W_t \equiv \left(\int_0^1 w_t(j)^{1-\epsilon_w} dj \right)^{\frac{1}{1-\epsilon_w}} \quad . \quad (4.8)$$

Using (4.7) and (4.8), firm i 's total wage bill can be expressed as:

$$\int_0^1 (1 + \tau_t^f) w_t(j) n_t(i, j) dj = (1 + \tau_t^f) W_t n_t(i) \quad , \quad (4.9)$$

where τ_t^f is the rate of employers' social contributions (set to zero in the scenario of taxing workers).

Total demand for the variety produced by firm i is given by

$$y_t(i) = \left(\frac{p_t(i)}{P_t} \right)^{-\epsilon} (C_t + G_t) \quad (4.10)$$

where $C_t = \int_0^1 c_t(j) dj$ is aggregate private consumption and G_t is public consumption. The government consumes the same final goods as households.

The price setting problem of a firm i allowed to re-optimize its price $p_t(i)$ is:

$$\max_{p_t(i)} \mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k} \theta^k [y_{t+k|t}(i) p_t(i) - \Psi_{t+k}(y_{t+k|t}(i))] \quad ,$$

4.2. THE MODEL

where $y_{t+k|t}(i)$ is period $t+k$ output if the price set today remains valid up to this period, which has probability θ^k . The stochastic discount factor is $Q_{t,t+k} \equiv \beta^k (c_{t+k}/c_t)^{-\gamma} (P_t/P_{t+k})$. The cost function $\Psi_t(\cdot)$ represents the firm's total wage bill (4.9), which under the use of (4.5) can be written as:

$$\Psi_{t+k}(y_{t+k|t}(i)) = (1 + \tau_{t+k}^f) W_{t+k} \frac{y_{t+k|t}(i)}{A_{t+k}} . \quad (4.11)$$

Optimal price setting (subject to demand schedule (4.10)) is governed by the following FOC that (jointly with (4.4)) implies a standard NKPC:

$$\mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k} \theta^k y_{t+k|t} \left[p_t^* - \frac{\epsilon}{(\epsilon-1)} (1 + \tau_{t+k}^f) W_{t+k} A_{t+k}^{-1} \right] = 0 . \quad (4.12)$$

The optimal new price p_t^* is a markup over an expected weighted average of effective marginal costs including the employer's portion of social security contributions. A change in τ_t^f ceteris paribus moves p_t^* and leads some firms to re-adjust prices, which is symbolized by the second arrow in Figure 4.1.

4.2.3 Unions and wage setting

Nominal wage rigidity is modeled as in Erceg et al. (2000). This feature is relevant for the analysis because it allows to account for allocative inefficiency stemming from wage dispersion. Households exert market power on the labor market because differentiated labor services are imperfect substitutes in (4.6). Each household j is represented by its own labor union that sets the household-specific wage rate $w_t(j)$ subject to a Calvo constraint, so only a random share $1 - \theta_w$ of unions can readjust each period. A union maximizes the expected present value of utility perceived by the household it represents:

$$\max_{w_t(j)} \mathbb{E}_t \left[\sum_{k=0}^{\infty} (\beta \theta_w)^k U(c_{t+k|t}(j), n_{t+k|t}(j)) \right] ,$$

where $c_{t+k|t}(j)$ and $n_{t+k|t}(j)$ are period $t+k$ consumption and hours, if the newly set wage is still valid. The optimal wage w_t^* satisfies the following FOC, that (jointly with (4.8)) governs the evolution of aggregate wages:

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\beta \theta_w)^k MU_{t+k|t} n_{t+k|t} \left[\left(1 - \tau_{t+k}^w\right) \frac{w_t^*}{P_{t+k}} - \frac{\epsilon_w}{(\epsilon_w - 1)} MRS_{t+k|t} \right] = 0 \quad (4.13)$$

where $n_{t+k|t} = (w_t^*/W_{t+k})^{-\epsilon_w} (N_{t+k}/s_{t+k}^w)$ is period $t+k$ total demand for type- j labor, given that w_t^* is valid.⁷ $MU_{t+k|t}$ and $MRS_{t+k|t}$ denote household j 's period $t+k$ marginal utility and marginal rate of substitution, also conditional on w_t^* . For w_t^* , it holds that after-tax real wages are a mark-up over an expected weighted average of marginal rates of substitution. Note that because unions take after-tax wages into account, they effectively negotiate over the wage inclusive of the employee's portion of social security contributions. A change in τ_t^w ceteris paribus affects w_t^* . The resulting wage re-adjustments are also symbolized by the second arrow in Figure 4.1.

⁷ N_t is the aggregate employment index (4.18) and s_t^w is a wage dispersion term, both introduced below. To derive this demand schedule, notice that a household charges the same wage to all firms renting its labor service, so (4.7) implies that total demand for type- j labor is given by $n_t(j) = \int_0^1 n_t(i, j) di = [w_t(j)/W_t]^{-\epsilon_w} \int_0^1 n_t(i) di$. From the derivation of (4.19) (see the Appendix) we know that $\int_0^1 n_t(i) di = N_t/s_t^w$. Substitution yields the equation.

4.2.4 Social security system

Following Burda & Weder (2016), the social security system is funded by payroll taxes and runs a balanced budget. The model allows contributions to be levied on firms or workers (rate τ_t^w or τ_t^f). Since revenues are reimbursed as lump-sum transfers, the social system is a simple redistribution device that is irrelevant for the income of households and does not provide any benefit. In contrast, it lowers welfare because it drives a wedge in the labor market, and because re-adjustments in the tax rate lead to price and wage re-adjustments, that in turn cause price and wage dispersion (the second and third arrow in Figure 4.1). The reason to include the social system is that the strength of the second mechanism by which it reduces welfare – i.e. causing price and wage dispersion – is shown to depend on the liability side.⁸ This dependency gives rise to the results of the paper. Abstracting from a meaningful role of the social system but accounting for the efficiency costs associated with its funding is suitable for the analysis in this paper. In section 4.4, welfare under firm taxation is compared to welfare under worker taxation, but the model is otherwise kept constant across the two scenarios. Hence, the potential welfare gain stemming from a meaningful social system would be the same in both scenarios, and thus would drop out in the comparison.

The budget of the social system reads as

$$(\tau_t^w + \tau_t^f) N_t W_t = s s b_t \quad . \quad (4.14)$$

The tax base is gross total labor compensation $N_t W_t$, regardless of whether taxes are levied on firms or workers. $s s b_t$ denotes the system's expenditures, which are reimbursed to households as lump-sum transfers. In the baseline model, $s s b_t$ is assumed to fluctuate exogenously, and is governed by

$$s s b_t = \overline{s s b} + \eta_t \quad \text{with} \quad \eta_t = \rho^{s s b} \eta_{t-1} + \epsilon_t^{s s b} \quad . \quad (4.15)$$

The term $\overline{s s b}$ denotes steady state expenditures and $\epsilon_t^{s s b} \sim N(0, \sigma^{s s b})$ induces innovations to the stochastic component η_t . Depending on whether the scenario is the taxation of firms or workers, one tax rate is set to zero:

$$\tau^w = 0 \text{ (if taxing firms)} \quad \text{or} \quad \tau^f = 0 \text{ (if taxing workers)} \quad (4.16)$$

For given tax base and given expenditures, (4.14) determines $(\tau_t^w + \tau_t^f)$ such that the budget is balanced. Since one of the two rates is set zero by (4.16), both rates are determined. The non-zero tax rate is referred to as social contributions rate or SCR. (4.14) and (4.16) jointly govern how the SCR adjusts in order to stabilize revenues in the face of fluctuations in the tax base. These adjustments are counter cyclical because the tax base tends to move with output, so upswings *ceteris paribus* require a downward-adjustment of the SCR to keep revenues constant (and the other way round in downturns). In Figure 4.1, this is symbolized by the first arrow.

Shocks to expenditures $s s b_t$ (induced by η_t) are an additional source of variation in the SCR, as they *ceteris paribus* require revenues to move accordingly under a balanced budget. Since $s s b_t$ is exogenous in the baseline model, SCR changes from this source are not correlated with output.⁹ Hence, a higher volatility of $s s b_t$ means that independent SCR fluctuations are stronger, so the SCR's negative correlation with output – induced by tax base movements – becomes weaker. This is exploited in the calibration of the model. As discussed in section 4.2.7, the dynamics of independent fluctuations (governed by $\rho^{s s b}$ and $\sigma^{s s b}$) is chosen such that resulting SCR dynamics resemble an empirically plausible pattern in a “calibration-scenario” of equal taxation of both sides. This is justified by the fact that the social system

⁸In contrast, the wedge is independent from the liability side, because hours worked are determined by after-tax real wages. The latter are the same under worker and firm taxation because of liability side equivalence.

⁹As a robustness check, $s s b_t$ is assumed to move counter cyclical, to account for the observed behavior of unemployment benefits (see the literature on automatic stabilizers). It is shown to strengthen the results of this paper.

is irrelevant for household income, which implies that the only effect that changes in ssb_t have in the model is to trigger adjustments in the SCR. Hence, the dynamics of ssb_t do not affect other variables apart from the SCR, and thus can be freely used to generate empirically plausible SCR-dynamics in the calibration-scenario.

With this calibration strategy the analysis can also be applied to countries that do not adhere to a balanced budget rule. Abandoning this rule means that when revenues and expenditures would *ceteris paribus* diverge, only a portion of the distance between the two variables is covered by adjusting revenues (i.e. by changing the SCR), while the remainder of the difference is covered by borrowing or lending. Empirically observed changes in the SCR reflect only the use of the first policy option to counteract an emerging divergence between revenues and expenditures. Calibrating (4.15) as to match observed SCR dynamics in the calibration-scenario therefore means that the model replicates only the portion of cyclical budgetary pressure that results in SCR adjustments. However, only this portion is relevant for the mechanism presented in this paper, since the latter emerges when SCR adjustments are used to balance the budget.

4.2.5 Fiscal and Monetary Policy

As common in the literature, exogenous disturbances in aggregate demand are introduced by stochastic government spending. G_t is defined as plain waste and exogenously determined by:

$$G_t = (1 - \rho^G) \bar{G} + \rho^G G_{t-1} + \epsilon_t^G, \quad (4.17)$$

with $\epsilon_t^G \sim N(0, \sigma^G)$.¹⁰ Expenditures are fully financed by lump-sum taxes in every period, so $G_t = tax_t$. Note that combining government consumption and social security into one entity would not change the model.

Monetary policy is assumed to target zero inflation. Its policy is governed by the following standard Taylor rule, where $\pi_{t+1} = P_{t+1}/P_t$:

$$R_t = \beta^{-1} + \alpha^\pi (\pi_{t+1} - 1) \quad .$$

4.2.6 Resource constraint

The constraint accounts for resource costs resulting from inefficiencies in the equilibrium allocation due to price and wage dispersion, which is symbolized by the third arrow in Figure 4.1. Closely related to Schmitt-Grohé & Uribe (2007), the relation between output of the final consumption good and the required amount of labor is established by defining aggregate employment N_t as total labor of all households j at all firms i :

$$N_t = \int_0^1 \int_0^1 n_t(i, j) di dj \quad . \quad (4.18)$$

As shown in the Appendix of this paper, it follows that:

$$N_t = s_t^p s_t^w \frac{C_t + G_t}{A_t} \quad , \quad (4.19)$$

where $s_t^p \equiv \int_0^1 (p_t(i) / p_t)^{-\epsilon} di$ and $s_t^w \equiv \int_0^1 (w_t(j) / w_t)^{-\epsilon_w} dj$ are dispersion terms, which are equal to their lower bound of 1 in the absence of dispersion.

¹⁰This specification of public spending is widely used in the literature, such as Evers (2012), for example.

4.2.7 Calibration

Table 4.1 shows the baseline calibration. The model is in quarters, and the calibration largely follows Evers (2012), who calibrates a related model to member countries of the European Monetary Union. Calvo probabilities for price and wage rigidity are chosen to match the empirical findings of Druant et al. (2009). In their study on the Euro Area, they report an average lifetime of prices and wages of 9.6 and 12.5 months respectively (excluding the outlier Italy). Elasticities of substitution between different good variations and labor types match 11% price mark-up and 15% wage mark-up, as estimated in Basu & Kimball (1997) and Chari et al. (2002). Steady state government consumption $\bar{G} = 0.2$ (22% of GDP) is also used in Evers (2012). The size of the social system in the steady state ssb is 14.2% GDP. This figure is at the higher end of the observed spectrum (see Table 4.5 in the Appendix), but well below the values observed in Austria, Belgium, the Czech Republic, France, Germany and the Netherlands.

For the stochastic component of social security expenditures, we use $\sigma^{ssb} = 0.0007$ (corresponding to a SD of 0.5% of steady state expenditures) and $\rho^{ssb} = 0.95$. This calibration is chosen because the model then generates moments $sd(scr) = 0.35\%$ and $corr(scr, gdp) = -0.4$ in the calibration-scenario of equal taxation of firms and workers, i.e. when using $\tau_t^w = \tau_t^f \forall t$ instead of (4.16). On the background of the empirical observations of $corr(scr, gdp)$ from Burda & Weder (2016) and analogously computed observations of $sd(scr)$ (see Table 4.4 and 4.6 in the Appendix), this can be regarded as a typical dynamic pattern.¹¹ Different dynamics are examined as a robustness check. The reason to target these moments under equal taxation of both sides is that they are shown to depend on the liability side, and are thus generated by different parameter depending on whether the tax is levied on firms or workers. Table 4.5 in the Appendix shows that the statutory breakdown of contributions between firms and workers varies widely across EU countries. Targeting the moments of the SCR under equal taxation of both sides constitutes an agnostic approach.

The calibration strategy for the exogenous processes of productivity and government spending is the same as in Evers (2012). The standard value of $\rho^A = 0.95$ is used for productivity shocks, while the remaining parameters ρ^G , σ^A and σ^G are calibrated as to match observed moments of government spending and output in the Euro Area.¹²

4.3 Shock adjustment under different liability sides

This section contrast the model adjustment to exogenous shocks under the taxation of firms and workers. In particular, we study deviations of social security expenditures (η_t in (4.15)), of productivity (A_t in (4.5)) and of government spending (ϵ_t^G in (4.17)). Throughout this section, lines without markers depict deviations in the scenario of the taxation of firms, while marked lines show the adjustment under the statutory taxation of workers.

¹¹The moments in Table 4.4 and 4.6 motivate the calibration of the quarterly model, but are computed for annual data. However, correlations do not change significantly when they are computed for quarterly data. In a working paper version of Burda & Weder (2016) (CEPR Discussion Paper No. 7984), the authors use quarterly data for 9 countries for which data in this frequency is available. For the whole sample period from 1970-2012, the following correlations are reported for quarterly data (the respective figures for annual data are shown in parenthesis): Germany -0.51 (-0.52), Sweden 0.09 (0.15), France -0.23 (-0.26), Netherlands -0.1 (-0.03), United Kingdom 0.1 (0.2), Finland -0.47 (-0.25), Japan -0.26 (-0.16), Canada -0.21 (-0.32), United States 0.15 (0.00).

¹²His sample covers nine European countries (Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) over the period 1999Q1 to 2007Q4. Applying an HP filter with smoothing parameter 1600 on data in logs, he reports standard deviations of output and government spending of 0.87% and 0.83% respectively. Targeting both moments as well as their ratio yields values of ρ^G , σ^A and σ^G that are roughly in line with his calibration.

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Table 4.1: Baseline calibration

Parameter		Value	Motivation / Target
β	Discount factor	0.99	Annual risk-free rate of 4%
γ	Relative risk aversion	1	Log-utility
ϕ^{-1}	Frisch elasticity of labor supply	1	Kimball & Shapiro (2008b)
ϵ	Elasticity of substitution goods variations	10	11% price mark-up, Basu & Kimball (1997)
ϵ_w	Elasticity of substitution types of labor	7.4	15% wage mark-up, Chari et al. (2002)
θ	Calvo probability firms	0.6875	Avg. lifetime 9.6 months, Druant et al. (2009)
θ_w	Calvo probability unions	0.76	Avg. lifetime 12.5 months, Druant et al. (2009)
α^π	Inflation coefficient in Taylor rule	1.5	Standard
\overline{G}	Steady state government spending	0.2	Evers (2012)
\overline{ssb}	Steady state social sec. expenditures	0.13	14.2% of steady state GDP
Shock processes			
σ^A	Std. innovations of technology process	0.0044	Matches $std(gdp)$ in the data
ρ^A	Persistence technology shock	0.95	Chari et al. (2002)
σ^G	Std. innovations of gov't spending process	0.0013	Matches $std(G)$ in the data
ρ^G	Persistence gov't spending shock	0.66	Matches $std(G)/std(gdp)$ in the data
σ^{ssb}	Std. innovations of social sec. expenditures	0.0007	} Matches data: $\sigma(scr_t) = 0.35\%$ and $\rho(scr_t, gdp_t) = -0.4$
ρ^{ssb}	Persistence social sec. expenditures	0.95	

4.3.1 Exogenous variation of expenditures

Figure 4.3 shows the adjustment to a reduction in social security expenditures ssb_t by 1% of steady state GDP. As outlined in section 4.2.4, the reduction in ssb_t itself is without consequence in the model, since it does not affect household income. However, the associated SCR-reduction – which is required under a balanced budget to lower revenues in line with expenditures – affects prices and wages, and thereby all other variables in general equilibrium. This SCR-adjustment is smaller under the taxation of workers (4th row, 2nd column), because the steady state tax base is larger in this case (as explained in the introduction), so a given SCR adjustment has a stronger impact on revenues.

Under the taxation of firms, the decline of the SCR directly reduces effective marginal costs (which include contributions), so firms reduce prices and the central bank responds by lowering the real interest rate. Consumption and output surge as a result. Regarding wages, we observe a decline in wage inflation but an increase in after-tax real wages. To see why, recall that labor unions' FOC (4.13) schedules a stabilization of expected after-tax real wages around a mark-up over expected marginal rates of substitution. The strong decline in prices elevates after-tax real wages above the level that is optimal for the equilibrium path of the MRS, so labor unions reduce nominal wages. The adjustment of wage inflation has a hump-shaped form because at the beginning of the adjustment, the downward pressure on wages is offset by the initial jump of the MRS, which in turn results from the initial surge in hours.

Turning to the taxation of workers (marked lines), we observe that the initial surge in output and hours has roughly one third of its magnitude under firm taxation. The reason is that the initial reduction in marginal costs is almost negligible in comparison to its adjustment under firm taxation, which implies a dramatically weaker decline in prices, leading the central bank to implement a more timid reduction in the real rate. The weaker decline in marginal costs is for two reasons. First, the SCR reduction does not directly affect marginal costs, as it is the case under firm taxation. Instead, a lower contributions rate only

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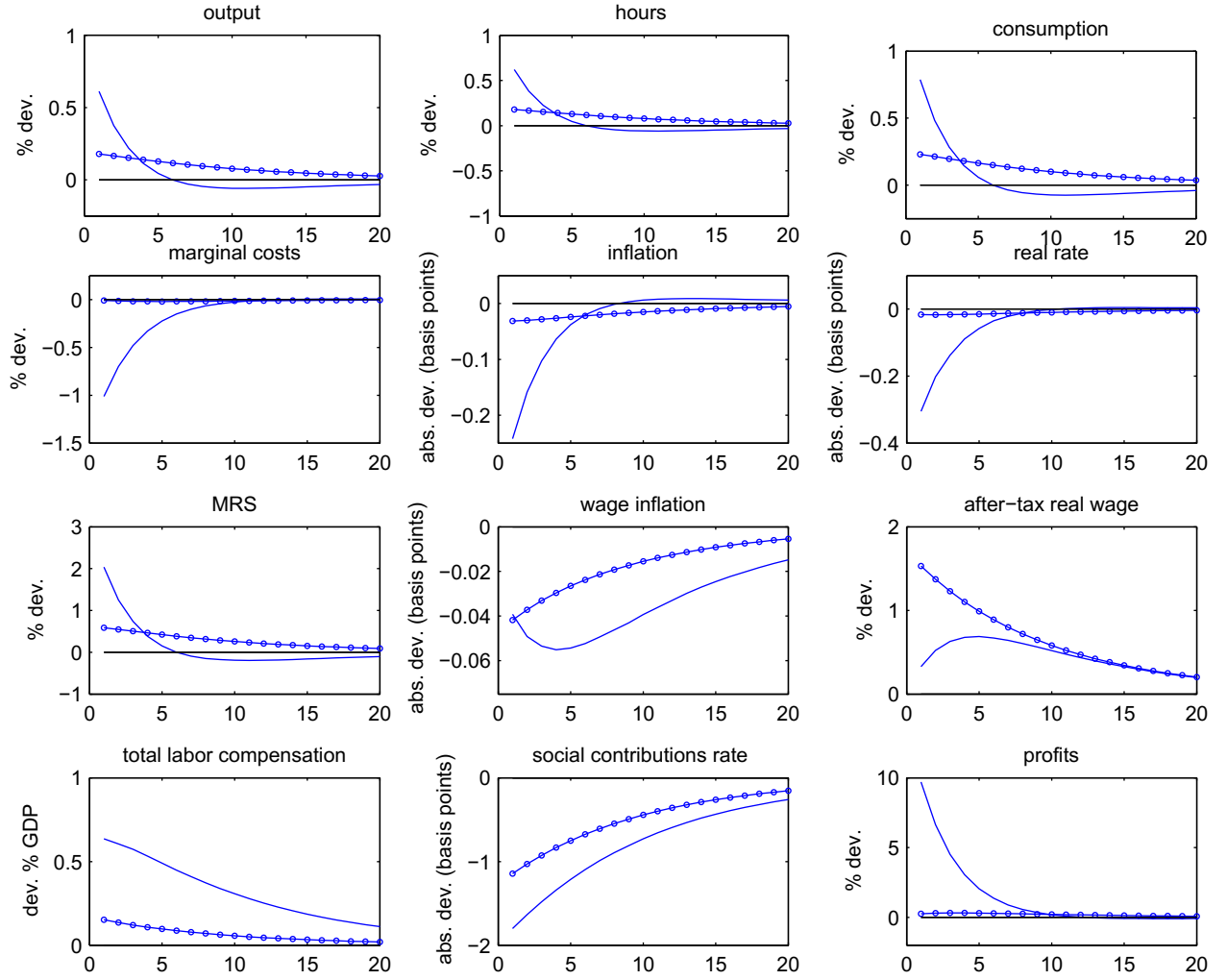


Figure 4.3: Reduction of social security benefits in the magnitude of 1% GDP.
Solid lines: taxing firms, **marked lines:** taxing workers

4.3. SHOCK ADJUSTMENT UNDER DIFFERENT LIABILITY SIDES

affects marginal costs to the extent that it leads to a staggered downward-adjustment of wages. Second, the decline in the SCR itself is weaker, as the steady state tax base is larger (see above). Regarding wages, we again observe a decline in newly set nominal wages but a rise in after-tax real wages. The reduction of social contributions paid by workers pushes after-tax wages on a level above the optimal one for the given path of the MRS, so newly set wages are lowered.

To conclude this exercise, note that under worker taxation, the reduction in social security expenditures causes a smaller deviation of output, consumption, prices and wages. While it is not surprising that prices are more stable – the SCR change is smaller and affects them only indirectly – it is noteworthy that also wages adjust by less under worker taxation, although the SCR change directly affect them in this case. This is due to the smaller size of the SCR adjustment, as well as to the negative deviation of the MRS after period 7, which lowers the optimal wage that unions seek to implement.

4.3.2 Productivity shocks

Figure 4.4 shows that the adjustment to a productivity shock is mildly different in both scenarios. In either case, the positive deviation of productivity (one SD of ϵ_t^A in (4.5)) reduces marginal costs and with it prices. This leads the central bank to lower the real interest rate, in turn causing households to increase consumption. Since the shock reduces the amount of hours required per unit of output, labor demand and hours decline despite the surge in GDP. The MRS deviates positively because the decline in marginal utility overcompensates the decline in the disutility of labor. In the wage setting decision of unions, the higher MRS is weighted against the decline in consumer prices that pushes up real wages. As the latter dominates, unions lower wages. Regarding the social security system, the shock raises total labor compensation, which would *ceteris paribus* cause a surge in revenues. Since expenditures remain unchanged, the balanced budget requires to lower the SCR in order to hold revenues constant as well. This SCR adjustment is smaller if contributions are levied on workers because the steady state tax base is higher (as discussed in the introduction).

All differences between the adjustment to the productivity shock in both scenarios originate from the different impact of the SCR-reduction, because the liability side is irrelevant for the shock adjustment if the SCR were constant. This allows us to explain the differences in the adjustment under both scenarios on the basis of the results from the previous exercise. Since the change in ssb_t is irrelevant for household income, the economy's adjustment in the previous exercise is fully attributed to the associated SCR-reduction. Because the SCR is also lowered in the course of the productivity shock, the adjustment discussed in the previous subsection is also present in this exercise – in addition to the impact of the productivity shock. For example, we observe that the adjustment path of wage inflation is lower under firm taxation. The reason is that the downward-adjustment of the SCR then exerts stronger downward-pressure on this variable, as shown in the previous exercise.

4.3.3 Demand shocks

Figure 4.7 in the Appendix shows the impact of a positive innovation in ϵ_t^G (equation (4.17)) in the magnitude of one standard deviation. Regarding the general adjustment, most of the additional government consumption is covered by a surge in output, implying a very mild consumption crowding out. This is due to wage rigidity: As nominal wages adjust slowly to the increment in disutility of labor, the rise in output only causes a moderate hike in marginal costs. This limits the induced inflation and thereby the strength of the resulting contractionary monetary policy stance. The output expansion implies an increase in total labor compensation, which requires a downward adjustment of the SCR. Unlike in the previous two exercises, there is no clear-cut picture on which liability side is favorable in terms of reducing fluctuations in macroeconomic aggregates. The welfare analysis will show that the taxation of workers reduces price and wage volatility, but only to a negligible extent.

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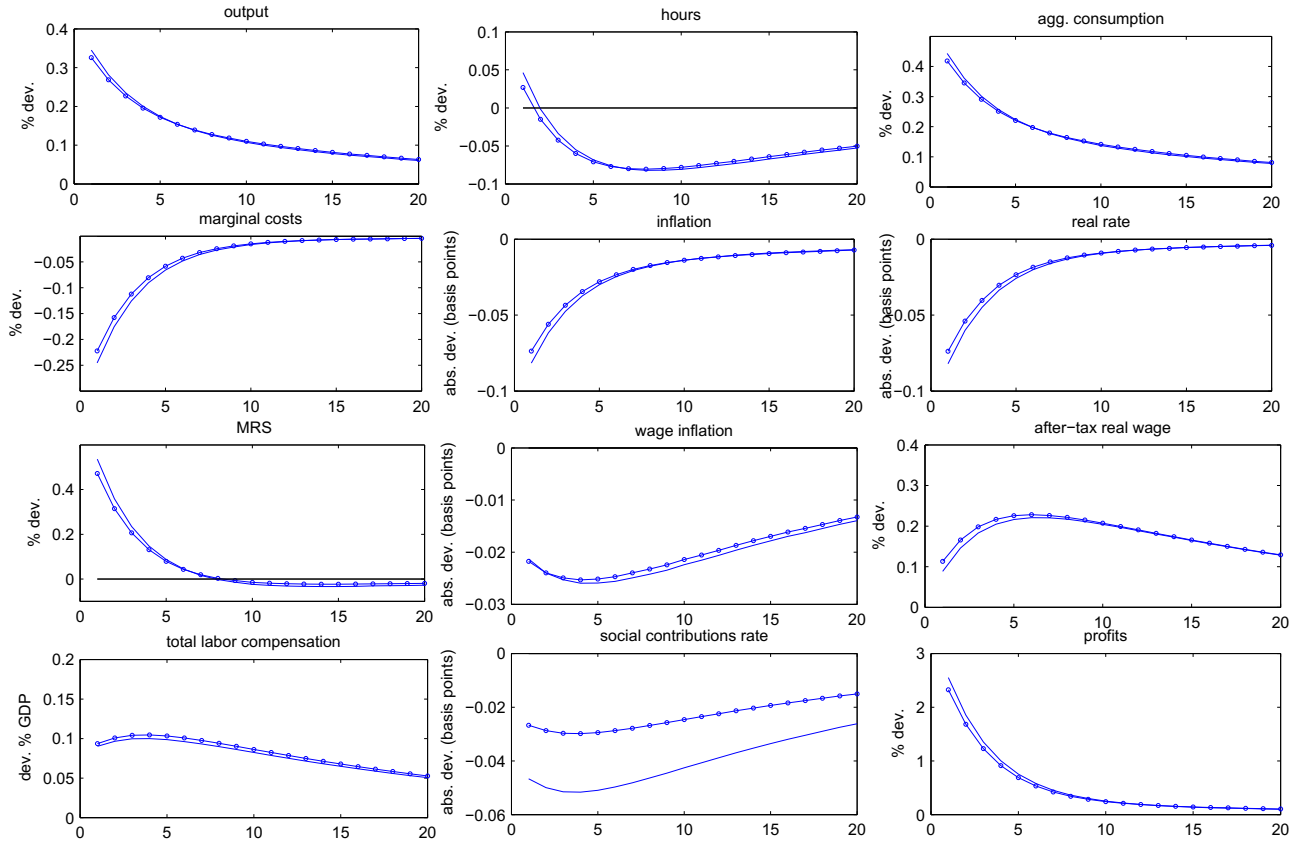


Figure 4.4: Positive one SD productivity shock.
Solid lines: *taxing firms*, **marked lines:** *taxing workers*

4.4 Welfare analysis

This section compares the welfare costs of business cycle fluctuations – measured by consumption compensation – under both liability sides. The consumption compensation ν is defined as the percentage reduction of consumption in the deterministic steady state for which an agent is equally well off in the deterministic steady state and in the stochastic environment.¹³ It is determined by:

$$\begin{aligned}\mathbb{E} \sum_{t=0}^{\infty} \beta^t U(c_t, n_t) &= \sum_{t=0}^{\infty} \beta^t U((1 + \nu^f) \bar{c}, \bar{n}) \quad (\text{if taxing firms}) \\ \mathbb{E} \sum_{t=0}^{\infty} \beta^t U(c_t, n_t) &= \sum_{t=0}^{\infty} \beta^t U((1 + \nu^w) \bar{c}, \bar{n}) \quad (\text{if taxing workers})\end{aligned}\tag{4.20}$$

The LHS denotes the unconditional expectation of household welfare in the ergodic distribution of the model with social contributions fully levied on the respective side. The model distribution is different under both liability sides because the latter affects the adjustment to shocks. The RHS is household welfare in the deterministic steady state, given that consumption is reduced by the respective consumption compensation ν^f or ν^w (which are negative). The allocation in the deterministic steady state is independent from the liability side because liability side equivalence holds in the flexible-price allocation. \bar{c} and \bar{n} are thus the same under both liability sides, so differences in the LHS between both scenarios translate into differences between ν^f and ν^w .

Following Evers (2012), both sides of (4.20) are approximated to express ν^f and ν^w as a function of first and second moments of the ergodic distribution. This allows us to decompose the total welfare loss into the following four components: The contributions of volatility in consumption and hours and the contributions of level effects in these two variables (defined as differences between the variables' unconditional expectations in the ergodic distribution and their value in the deterministic steady).¹⁴ To obtain the moments used in the welfare function, the model is written recursively as in Schmitt-Grohé & Uribe (2007) and solved in Dynare by a second-order accurate perturbation method. To eliminate the inaccuracy involved in simulating the model, population moments are computed analytically by applying the nonlinear moving average method of Lan & Meyer-Gohde (2013). This approach withstands the critique of Kim & Kim (2003), who show that meaningful welfare analyses require at least a second-order accurate approximation to the system of equations.

4.4.1 Welfare results

Table 4.2 presents the results of the welfare analysis and moments of selected variables. Labels “Workers” and “Firms” indicate that the tax is levied on the respective side. The figures are reported for the full stochastic setup (labeled “All shocks”), as well as for two setups in which either demand shocks or productivity shocks are deactivated. For the reported moments, columns labeled “%-diff” show their difference under both liability sides, as a percentage share of the value under worker taxation. The same holds for the total welfare loss, where a positive value indicates that the loss becomes more severe under firm taxation (the negative compensation becomes larger). For the four components of the welfare loss, “%-diff” also presents differences between both scenarios, but as a share of the total loss under worker taxation. Here, a positive value indicates that the respective component contributes to a worsening of the welfare loss under firm taxation, while a negative value means that the component mitigates the loss.¹⁵

Before we compare the outcomes under both liability sides, we make two general observations that hold in either scenario. First, in each of the three stochastic setups, level effects greatly dominate volatility

¹³This commonly applied measure goes back to Lucas (1987) and Lucas (2003).

¹⁴Details on the functions and their derivation are provided in the Appendix.

¹⁵For example, in the full stochastic setup, lower mean consumption under firm taxation increases this component of the welfare loss, in a magnitude that corresponds to 15.58% of the total loss under worker taxation. In contrast, fewer hours worked under firm taxation mitigate the welfare loss by 4.31% of the total loss under worker taxation.

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effects in the decomposition of the welfare loss.¹⁶ Second, the total welfare loss if there are no productivity shocks is insignificant compared to the loss that arises if there are no demand shocks.¹⁷ Hence, since demand shocks and volatility effects are of secondary importance, we can focus on level effects caused by productivity shocks to explain the total welfare loss in the full stochastic setup.

Table 4.2: Welfare costs of fluctuations, baseline model

	All shocks			No demand shocks			No productivity shocks		
	Workers	Firms	%-diff.	Workers	Firms	%-diff.	Workers	Firms	%-diff.
Welfare loss of fluctuations	-0.0800	-0.0890	11.25	-0.0797	-0.0887	11.29	-0.0009	-0.0025	171.10
Decomposition:									
Level cons.:	-0.1458	-0.1582	15.58	-0.1455	-0.1580	15.64	-0.0016	-0.0039	246.70
Level hours:	0.0735	0.0770	-4.31	0.0734	0.0768	-4.35	0.0010	0.0017	-71.07
Volatility cons.:	-0.0061	-0.0061	-0.02	-0.0061	-0.0061	-0.03	-0.0001	-0.0001	-2.53
Volatility hours:	-0.0016	-0.0016	0.01	-0.0015	-0.0015	0.02	-0.0002	-0.0002	-1.99
Moments									
Mean output*	0.9165	0.9164	-0.08	0.9165	0.9164	-0.08	0.9176	0.9176	-0.02
Mean consumption*	0.7166	0.7165	-0.12	0.7166	0.7165	-0.12	0.7176	0.7176	-0.02
Mean hours*	0.9169	0.9168	-0.04	0.9169	0.9168	-0.04	0.9176	0.9176	-0.01
Std. dev. consumption	0.0079	0.0078	-0.32	0.0079	0.0078	-0.32	0.0010	0.0008	-13.54
Std. dev. hours	0.0056	0.0056	2.26	0.0053	0.0054	4.60	0.0020	0.0019	-48.77
Std. dev. SCR	0.0031	0.0041	35.78	0.0030	0.0041	35.88	0.0029	0.0039	35.57
Std. dev. inflation	0.0028	0.0029	5.99	0.0028	0.0029	5.98	0.0001	0.0005	264.66
Std. dev. wage inflation	0.0017	0.0018	2.87	0.0017	0.0018	2.87	0.0001	0.0002	66.00
Mean disp. good variations**	0.2720	0.3054	12.29	0.2720	0.3053	12.27	0.0008	0.0100	1229.78
Mean disp. labor types**	0.1453	0.1537	5.78	0.1452	0.1536	5.79	0.0011	0.0031	175.54

*Differences are reported in units per mill.

**Dispersion terms are reported as deviations from one in units per mill.

These level effects arise because productivity is lower in the stochastic environment, which leads households to work fewer hours and consume less (which lowers welfare since the loss from forgone consumption is roughly three times as large as the gain from more leisure). The source of the productivity loss is price and wage volatility, which is under Calvo-rigidity accompanied by dispersion among prices and wages.¹⁸ Price dispersion leads households to consume different quantities of different good variations, while wage dispersion leads firms to employ different amounts of different types of labor. As a result, Jensen's Inequality applies in aggregators (4.2) and (4.6) and raises the total amount of good variations required to bundle one unit of the final good, as well as the amount of total labor required to bundle one unit of the labor composite. Less output of the final good for given labor input means that productivity is lower, which manifests in the aggregate resource constraint (4.19) as resource costs.

Finally turning to the comparison of model distributions under both liability sides, we observe that in the full stochastic setup, total welfare costs are by 11.25% higher under firm taxation. The reason is that SCR-adjustments are dramatically larger, implying that the SCR's standard deviation is by 35.78% higher than under worker taxation – in line with the shock adjustments shown in Figures 4.3 and 4.4.

¹⁶Consider for example the full stochastic setup and the taxation of workers. Summing up over consumption and hours, level effects cause a welfare loss of $-0.1458 + 0.0735 = -0.0723$ units, while volatility effects lead to a loss of $-0.0061 - 0.0016 = -0.0077$ units.

¹⁷This observation fits the explanation of Figure 4.1, which attributes the welfare loss to nominal volatility. Comparing the adjustment to productivity and demand shocks (Figures 4.4 and 4.7) shows that a productivity shock induces about ten times stronger deviations of price and wage inflation, although the impact on output only differs by the factor two. Productivity disturbances are thus substantially more relevant for nominal volatility.

¹⁸Whenever the optimal price (wage) changes, entities that are allowed to re-adjust set a price (wage) different from the price (wage) that remains valid for the non-adjusting entities.

Larger SCR-adjustments lead to stronger adjustments in prices and wages, so the standard deviations of price and wage inflation are by 5.99% respectively 2.87% higher than under worker taxation.¹⁹ Higher nominal volatility increases mean price and wage dispersion by 12.29% and 5.78% respectively, implying a stronger productivity loss. The latter leads to lower output, consumption and hours worked. This increases the welfare loss, because the gain from working fewer hours (4.31% of the total loss under worker taxation) is dominated by the loss from lower consumption (15.58% of the total loss under worker taxation).

Up to this point, model distributions under the exclusive taxation of firms respectively workers were compared. Figure 4.6 in the Appendix considers intermediate cases, by plotting the welfare loss as a function of the statutory share of contributions levied on firms. The loss depends almost perfectly linear on the statutory breakdown of social contributions between firms and workers.

4.5 Robustness analysis

Before we consider variations of key parameter values, we first modify the dynamics of social security expenditures (ssb_t in (4.15)) in order to generate different SCR-dynamics in the calibration-scenario of equal taxation of firms and workers. Again note that changes in ssb_t only affect other variables via the associated SCR-adjustments (see section 4.2.4), so the dynamics of ssb_t are a suitable device to introduce different SCR-dynamics. In order to allow for a broad set of dynamics in ssb_t , an ad-hoc dependency of ssb_t on output fluctuations is introduced. To this aim, the time-variant component of ssb_t in equation (4.15) is governed by

$$\eta_t = \rho^{ssb} \eta_{t-1} + \epsilon_t^{ssb} + \alpha \epsilon_t^A, \quad (4.21)$$

where $\epsilon_t^{ssb} \sim N(0, \sigma^{ssb})$ induces independent fluctuations, ϵ_t^A is the stochastic innovation of productivity shocks (see (4.5)), and α is an exogenous weight. The dependency of η_t (and thereby of ssb_t) on ϵ_t^A allows us to adjust the strength of the cyclical behavior of the SCR. A negative value of α strengthens the countercyclicality of the SCR, because in this case, a positive technology shock ($\epsilon_t^A > 0$) does not only cause a surge in the tax base (see Figure 4.4), but also an reduction in ssb_t . Hence, the downward-adjustment that is required to offset the raising tax base is reinforced by the need to lower revenues in line with declining expenditures. Vice versa, $\alpha > 0$ weakens the countercyclicality of the SCR: a positive technology shock then leads to higher social security expenditures, which counteracts the downward-adjustment in the SCR that stems from the surging tax base.

Figure 4.5 shows the percentage increase in welfare costs under firm taxation relative to worker taxation – derived in the same way as in Table 4.2 – as a function of SCR-dynamics in the calibration-scenario (summarized by $sd(scr)$ and $corr(scr, gdp)$).²⁰ The figure reported in Table 4.2 is found at $sd(scr) = 0.35\%$ and $-corr(scr, gdp) = 0.4$. The table next to the figure contains the same information as the plot.

The difference in welfare costs between both scenarios increases in $sd(scr)$ and in $-corr(scr, gdp)$. The increment in $sd(scr)$ is straightforward to explain: Under worker taxation, a given adjustment in revenues can be implemented by a smaller change in the contributions rate. However, a low value of $sd(scr)$ in the calibration-scenario means that required adjustments in revenues are small on average, so the liability side makes less of a difference for SCR-volatility and thereby for welfare. To explain why the welfare difference increases in $-corr(scr, gdp)$, first note that SCR-adjustments can offset some of the adjustment pressure on prices and wages that results from shocks driving business cycle fluctuations. This occurs whenever the adjustment pressure on nominal variables resulting from an SCR-adjustment

¹⁹This is also in line with Figures 4.3 and 3.4.

²⁰For each point on the $sd(scr)$ - $corr(scr, gdp)$ plane, α and σ^{ssb} are adjusted such that the respective moments are generated by the model under equal taxation of firms and workers. Then, for each point, the difference in the welfare loss under worker and firm taxation computed and plotted.

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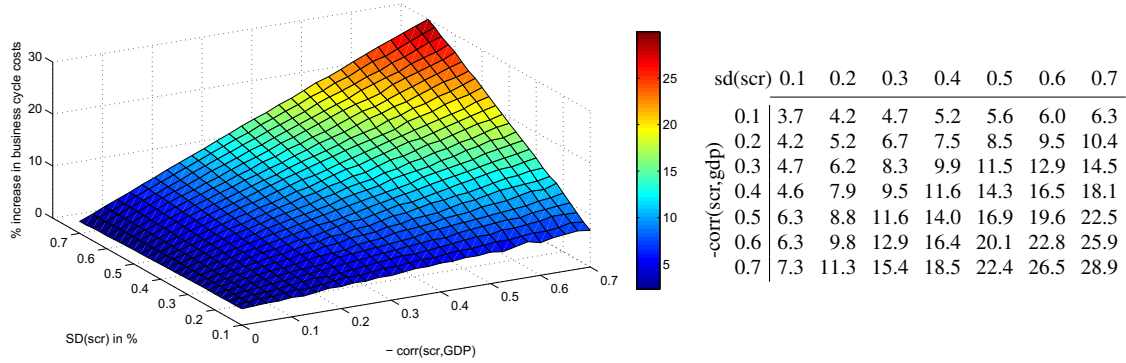


Figure 4.5: Welfare results in dependency of baseline SCR-dynamics.

has the opposite direction than the adjustment pressure from a business cycle shock. Such an offset leads to a reduction in the overall size of price and wage adjustments. The higher the probability of an offset, the lower is the reduction in nominal volatility that can be achieved by reducing the average size of SCR-adjustments. The reason is that by downsizing SCR-adjustments, one also mitigates the size of the reduction in nominal adjustments that results from an offset. In the extreme case of $corr(scr, gdp) = 0$, SCR-adjustments are independent from shocks that drive business cycle fluctuations of output, so the probability of an offset is 50%. In this case, lowering the expected size of SCR-adjustments by taxing workers instead of firms leads to virtually no reduction in nominal volatility and welfare costs. The reason is that the mitigation of the consequences of an offset balances out with the reduction in nominal adjustment from SCR-adjustments when there is no offset. With higher values of $-corr(scr, gdp)$, the likelihood of an offset is declining, because an offset typically occurs when an output deviation and an SCR-adjustment have the same direction.²¹ This means that the adverse side effect of having smaller SCR-adjustments under worker taxation – i.e. to limit the impact of offsets – becomes less important. As a result, taxing workers causes a stronger reduction of nominal volatility and welfare costs.

Quantitatively, the welfare implications of the liability side are significant already for a mild counter-cyclicality and a mild volatility of the SCR – which is in general the case, given the observed dynamics reported in Table 4.4 and 4.6.

4.5.1 Sensitivity to model parameters

Table 4.3 shows welfare results and moments of selected variables in the same way as Table 4.2, but for several parameter variations. For each parameter variation, the calibration of expenditures (4.21) is adjusted such that $sd(scr) = 0.35\%$ and $corr(scr, gdp) = -0.4$ are valid in the calibration-scenario of equal taxation of both sides. Without these adjustments, SCR-dynamics in the calibration-scenario would differ across parameter variations because the latter affect the dynamics of total labor compensation (the tax base), and thereby of social security revenues.

²¹ Since most of the variation in GDP stems from productivity shocks, GDP tends to move in the opposite direction than prices and wages (see Figure 4.4). In contrast, SCR-adjustments drag prices and wages in their own direction (see Figure 4.3). Hence, when a productivity-induced output deviation and a SCR-adjustment have the opposite direction, the adjustment pressure on nominal variables from both sources has the same direction.

4.5. ROBUSTNESS ANALYSIS

	Total Loss	Level Cons.	Level Hours	Vola. Cons.	Vola. Hours	—	$\mathbb{E}(\text{output})$	$\mathbb{E}(\text{cons.})$	$\mathbb{E}(\text{hours})$	SD(cons.)	SD(hours)	SD(SCR)	SD(inflation)	SD(wage infl.)	$\mathbb{E}(\text{good disp.})$	$\mathbb{E}(\text{labor disp.})$
Baseline calibration																
Workers	-0.0800	-0.1458	0.0735	-0.0061	-0.0016		0.9165	0.7166	0.9169	0.0079	0.0056	0.0031	0.0028	0.0017	0.2720	0.1453
Firms	-0.0890	-0.1582	0.0770	-0.0061	-0.0016		0.9164	0.7165	0.9168	0.0078	0.0056	0.0041	0.0029	0.0018	0.3054	0.1537
%-diff.	11.25	15.58	-4.31	-0.02	0.01		-0.08	-0.12	-0.04	-0.32	2.26	35.78	5.99	2.87	12.29	5.78
Exercise A: $\alpha^\pi = 1.301$ Less responsive monetary policy																
Workers	-0.1178	-0.2331	0.1220	-0.0042	-0.0025		0.9158	0.7160	0.9163	0.0064	0.0069	0.0030	0.0031	0.0021	0.3483	0.2304
Firms	-0.1286	-0.2478	0.1259	-0.0042	-0.0025		0.9157	0.7159	0.9163	0.0063	0.0069	0.0041	0.0033	0.0022	0.3822	0.2393
%-diff.	9.22	12.50	-3.28	-0.02	0.02		-0.09	-0.15	-0.05	-0.78	3.43	35.76	4.77	1.93	9.72	3.84
Exercise B1: $\theta = \theta_w = 0.75$ Prices and wages equally rigid																
Workers	-0.0842	-0.1349	0.0589	-0.0068	-0.0014		0.9166	0.7167	0.9170	0.0083	0.0052	0.0030	0.0025	0.0017	0.3698	0.1257
Firms	-0.0931	-0.1458	0.0610	-0.0068	-0.0014		0.9165	0.7166	0.9170	0.0083	0.0052	0.0041	0.0026	0.0017	0.4109	0.1323
%-diff.	10.53	13.00	-2.51	0.04	0.00		-0.07	-0.11	-0.03	0.16	0.02	35.17	5.44	2.57	11.12	5.18
Exercise B2: $\theta = 0.8, \theta_w = 0.667$ Prices more rigid than wages																
Workers	-0.0798	-0.0892	0.0195	-0.0094	-0.0008		0.9170	0.7170	0.9174	0.0098	0.0039	0.0030	0.0023	0.0017	0.5091	0.0655
Firms	-0.0865	-0.0955	0.0192	-0.0095	-0.0007		0.9169	0.7170	0.9174	0.0099	0.0039	0.0041	0.0024	0.0017	0.5530	0.0679
%-diff.	8.42	7.87	0.42	0.14	-0.01		-0.04	-0.06	0.00	0.55	-2.95	35.34	4.24	1.79	8.62	3.59
Exercise B3: $\theta = 0.667, \theta_w = 0.8$ Wages more rigid than prices																
Workers	-0.0857	-0.1706	0.0915	-0.0041	-0.0025		0.9163	0.7164	0.9167	0.0064	0.0070	0.0030	0.0027	0.0015	0.2266	0.1757
Firms	-0.0954	-0.1850	0.0961	-0.0040	-0.0026		0.9162	0.7163	0.9166	0.0063	0.0071	0.0041	0.0029	0.0016	0.2556	0.1861
%-diff.	11.35	16.81	-5.42	-0.08	0.05		-0.10	-0.14	-0.06	-1.19	6.79	35.13	6.23	2.92	12.80	5.90
Exercise C: $\overline{ssb} = 0.09$ Smaller social security system																
Workers	-0.0739	-0.1409	0.0748	-0.0060	-0.0017		0.9400	0.7402	0.9404	0.0081	0.0057	0.0032	0.0028	0.0017	0.2714	0.1444
Firms	-0.0817	-0.1520	0.0780	-0.0060	-0.0017		0.9400	0.7401	0.9404	0.0081	0.0058	0.0039	0.0029	0.0017	0.3058	0.1526
%-diff.	10.54	14.94	-4.37	-0.05	0.02		-0.08	-0.11	-0.04	-0.43	3.93	22.57	6.16	2.81	12.67	5.66
Exercise D: $\phi = 2$ Increased curvature of labor disutility																
Workers taxed	-0.1186	-0.2567	0.1475	-0.0053	-0.0040		0.9415	0.7416	0.9419	0.0074	0.0063	0.0030	0.0027	0.0016	0.2640	0.1322
Firms taxed	-0.1301	-0.2765	0.1558	-0.0053	-0.0041		0.9414	0.7415	0.9418	0.0074	0.0064	0.0041	0.0029	0.0017	0.3001	0.1403
%-diff.	9.77	16.70	-7.00	-0.01	0.08		-0.14	-0.20	-0.10	-0.64	8.79	34.13	6.66	3.06	13.71	6.13
Differences in means are reported in units per mill, and dispersion terms as deviations from one in units per mill.																

Table 4.3: Robustness exercises.

THIRD ESSAY ON LIABILITY-SIDE EQUIVALENCE

Exercise A: Less responsive monetary policy

$\alpha^\pi = 1.301$ reduces the responsiveness of monetary policy relative to the baseline calibration. This parameter approximates the monetary policy stance faced by a member country of the Euro Zone “core region” defined as Germany, France, Austria, Belgium and the Netherlands. A large body of literature reports a high degree of business cycle synchronization among these countries.²² Under the simplifying assumption of perfect synchronization, monetary policy reacts to inflation in a “core region”-country with the same strength as to inflation in a hypothetical country that has the size of the entire “core region” taken together.²³ The “core region” covers more than half of the population of the Euro Zone, and has a weight of 60.2% in the ECB’s average inflation measure (using 2014 HICP country weights). In order to adjust the responsiveness of the real interest rate accordingly, the active portion of monetary policy (i.e., the change of the nominal interest rate in excess of the inflation rate) is weighted by 0.602. This yields a Taylor coefficient of $\alpha^\pi = 1 + 0.5 * 0.602 = 1.301$. For this calibration, the welfare loss is by 9.22% higher under firm taxation, which is a slight reduction of the liability side’s welfare implications relative to the main calibration.

Exercises B1, B2 and B3: Varying price and wage rigidity

Exercises B1, B2 and B3 investigate the role of nominal rigidity of prices and wages. B1 considers the case of symmetric price and wage rigidity. It sets $\theta = \theta_w = 0.75$ (implying a one-year expected lifetime of prices and wages), which increases price rigidity relative to the baseline calibration, but leaves wage rigidity almost unchanged. With a difference in the welfare loss of 10.53%, the results do not change significantly. B2 and B3 consider non-symmetric rigidity: In B2, prices are expected to last for 5 quarters ($\theta = 0.8$), while wages are significantly more flexible and have a lifetime of only 3 quarters ($\theta_w = 0.667$). B3 considers the opposite case, in which prices are expected to last for only 3 quarters, but wages for 5 quarters ($\theta = 0.667$ and $\theta_w = 0.8$). The results show that when prices are more rigid than wages, the welfare implication of the liability side decreases to 8.42%. However, in the more plausible case of higher wage rigidity (which closely resembles the baseline calibration), the figure is 11.35%.

Exercise C: Smaller social security system

This exercise sets $\overline{ssb} = 0.09$, which implies a steady state size of the social security system of 10% GDP (compared to 14.2% in the baseline calibration). This value is at the lower end of the range observed in OECD countries: Only Denmark, Ireland, Norway, Portugal and the UK have smaller social systems. Under this calibration, the difference between the welfare loss under both liability sides is 10.54%, a slight reduction compared to the main calibration.

Exercise D: Increased curvature of labor disutility

The baseline-parameter for the Frisch elasticity of labor supply $1/\phi = 1$ is common in the New Keynesian literature. To check the robustness with regard to this parameter, exercise D considers the value $\phi = 2$, which implies a Frisch elasticity of 0.5. The results show that the effect on the difference between the welfare loss under both liability sides is weak: Business cycle costs are by 9.77% higher if contributions are levied on firms.

²²See e.g. De Haan et al. (2008) and Jones et al. (2012), or the classic study of Bayoumi & Eichengreen (1994), who report a high synchronization of supply shocks.

²³Under perfect synchronization, inflation rates are perfectly correlated across “core region” countries, so each country has effectively the same weight in the ECB’s Taylor rule as the entire “core region” as a whole.

4.6 Conclusion

This paper shows that the liability side of social security contributions matters in a New-Keynesian DSGE model for the volatility of prices and wages, and thereby for the welfare loss of business cycle fluctuations. Calibrating the model to a typical Eurozone country with a sizable welfare system, taxing workers lowers price and wage volatility by 5.99% and 2.87% relative to the taxation of firms, which implies a reduction of the welfare loss by 11.25%.

In the unconditional mean of the model distribution, all agents are better off under worker taxation, while the ratio between after-tax profits and after-tax labor income is independent from the liability side due to liability side equivalence. However, a regime switch towards worker taxation causes transitory redistribution of labor income towards firm profits. The reason is that nominal rigidity prevents wages to adjust instantaneously when the nominal tax burden is shifted towards workers. Hence, the initial ratio between after-tax firm profits and after-tax labor income is only restored – and the transitory redistribution undone – when the nominal adjustment to the tax shift is completed. This has to be taken into account in a normative evaluation of the policy.

The structure of the model is rich enough to generate the role of the liability side, but abstracts from features that are potentially relevant for the finding. The introduction of credit-constrained households that do not earn profit income (Galí et al. (2004)) constitutes a promising extension of the model. With this feature, above mentioned transitory fluctuations in the ratio between labor income and profits imply redistribution between the two groups of households. This in turn affects aggregate demand because credit-constrained households have a propensity to consume of one. Since the liability side would determine the direction of the cyclical redistribution, it would have further implications for the business cycle. Other promising directions for future research are the inclusion of capital and allowing for trade in an open economy setup. The latter is especially interesting in the context of a monetary union. The literature on optimum currency areas identifies price stickiness as the root cause for the costs of belonging to a union.²⁴ The liability side, with its impact on cyclical price setting, could be of relevance for these costs.

²⁴See Mundell (1961), McKinnon (1963) and Kenen (1969) for classic contributions.

4.7 Appendix

Derivation of (4.19):

Starting with

$$N_t = \int_0^1 \int_0^1 n_t(i, j) di dj = \int_0^1 \int_0^1 \frac{n_t(i, j)}{n_t(i)} n_t(i) di dj \quad ,$$

one can use (4.7) to substitute for the fraction:

$$= \int_0^1 \int_0^1 \left(\frac{w_t(j)}{W_t} \right)^{-\epsilon_w} n_t(i) di dj = \int_0^1 \left(\frac{w_t(j)}{W_t} \right)^{-\epsilon_w} \int_0^1 n_t(i) di dj$$

as the inner integral is constant in j ,

$$= \int_0^1 \left(\frac{w_t(j)}{W_t} \right)^{-\epsilon_w} dj \int_0^1 n_t(i) di = s_t^w \int_0^1 n_t(i) di.$$

Equating the production function (4.5) with firm-specific total demand (4.10) to evoke market clearing on the firm level, one obtains $n_t(i) = \left(\frac{p_t(i)}{P_t} \right)^{-\epsilon} \frac{C_t + G_t}{A_t}$. Substituting yields:

$$= s_t^w \int_0^1 \left(\frac{p_t(i)}{P_t} \right)^{-\epsilon} di \frac{C_t + G_t}{A_t} = s_t^w s_t^p \frac{C_t + G_t}{A_t} \quad .$$

Derivation of welfare functions:

The sum on the LHS of (4.20) adds unconditional expectations of future period utilities (as well as today's period utility) in the ergodic distribution. The sum on the RHS adds today's and future period utilities in the deterministic steady state, with consumption adjusted by ν . Unconditional expectations as well as deterministic steady state values are constant over time. Using a geometric series, (4.20) can therefore be written as:

$$\frac{1}{1-\beta} \mathbb{E} U(c_t, n_t) = \frac{1}{1-\beta} U((1+\nu)\bar{c}, \bar{n})$$

\Leftrightarrow

$$\mathbb{E}[U(c_t, n_t)] = U((1+\nu)\bar{c}, \bar{n}) \quad .$$

Consider the LHS. Applying a second-order Taylor approximation in c_t and n_t around the deterministic steady state yields

$$\bar{U} + \bar{U}_C \mathbb{E}[c_t - \bar{c}] + \frac{\bar{U}_{CC}}{2} \mathbb{E}[c_t - \bar{c}]^2 + \bar{U}_N \mathbb{E}[n_t - \bar{n}] + \frac{\bar{U}_{NN}}{2} \mathbb{E}[n_t - \bar{n}]^2 \quad ,$$

where the bar denotes variables in the deterministic steady state and the cross term is neglected, as commonly done in the literature. Now consider the RHS. Applying a first-order Taylor approximation in ν around the deterministic steady state yields:

$$\bar{U} + \frac{\delta \bar{U}}{\delta \nu} \nu \quad .$$

It follows that the total consumption compensation for business cycle fluctuations ν is the sum of the following components:

$$\begin{aligned} \nu_{\text{mean C}} &= \left(\partial \bar{U} / \partial v \right)^{-1} \bar{U}_C \mathbb{E}[c_t - \bar{c}] \\ \nu_{\text{mean N}} &= \left(\partial \bar{U} / \partial v \right)^{-1} \bar{U}_N \mathbb{E}[n_t - \bar{n}] \\ \nu_{\text{volatility C}} &= \left(\partial \bar{U} / \partial v \right)^{-1} 0.5 \bar{U}_{CC} \mathbb{E}[c_t - \bar{c}]^2 \\ \nu_{\text{volatility N}} &= \left(\partial \bar{U} / \partial v \right)^{-1} 0.5 \bar{U}_{NN} \mathbb{E}[n_t - \bar{n}]^2 \end{aligned}$$

Tables and Graphs:

Table 4.4: Payroll taxes over time, correlation between SCR and GDP

	Ratio of payroll taxes to total compensation		Correlation of annual payroll payroll tax rate with GDP*		
	1970-89	1990-2012	1970-1989	1990-2012	1970-2012
Germany	0.28	0.34	-0.48	-0.56	-0.51
Sweden	0.24	0.29	-0.56	0.41	0.13
France	0.37	0.41	-0.19	-0.34	-0.28
Netherlands	0.31	0.29	-0.47	0.19	-0.01
UK	0.22	0.26	0.29	0.12	0.22
Denmark	0.09	0.16	-0.04	0.20	0.15
Finland	0.14	0.15	-0.47	-0.15	-0.22
Japan	0.17	0.25	-0.45	-0.05	-0.24
Belgium	0.32	0.39	-0.69	-0.57	-0.63
Italy	0.36	0.38	-0.30	-0.04	-0.10
Austria	0.30	0.35	-0.41	-0.58	-0.50
Australia	0.01	0.01	-0.34	0.04	-0.23
Norway	0.23	0.21	0.21	-0.07	0.14
Canada	0.07	0.09	-0.30	-0.33	-0.32
New Zealand		0.10		0.33	0.25
South Korea	0.10	0.18	-0.44	-0.43	-0.39
Spain	0.25	0.30	-0.65	-0.24	-0.38
US	0.10	0.12	0.29	-0.48	-0.02

Source: Burda & Weder (2016), data from OECD.

*Tax rates and log real GDP are HP-filtered with a smoothing parameter $\lambda = 6.25$.

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Table 4.5: Social security systems in the EU, 2012

	Social security contributions, % of GDP	Employee's share in %
Austria	14.5	40
Belgium	14.2	30
Czech Republic	15.4	20
Denmark	1.0	95
Estonia	11.9	7
Finland	12.6	22
France	16.7	24
Germany	14.2	44
Greece	10.6	39
Hungary	12.9	60
Ireland	4.6	23
Italy	13.4	18
Luxembourg	11.0	46
Netherlands	14.8	43
Norway	9.5	33
Poland	11.4	40
Portugal	9.3	39
Slovak Republic	12.3	24
Spain	12.1	16
Sweden	10.1	26
UK	6.7	40

Source: OECD Revenue Statistics 2012.

Table 4.6: Volatility of social contributions rate

Country	Std. dev. SCR in %	Sample
Austria	0.21	76-13
Belgium	0.19	95-13
Cyprus	0.42	95-13
Germany	0.38	91-13
Estonia	0.46	95-14
Spain	0.13	95-13
Finland	0.73	75-13
France	0.32	74-14
Greece	0.75	00-13
Italy	0.65	92-14
Luxembourg	0.24	85-14
Latvia	0.86	92-13
Malta	0.16	95-13
Netherlands	0.83	71-13
Portugal	0.22	95-13
Slovenia	0.20	91-13
Slovakia	1.19	95-14

SCR constructed as social contributions divided by compensation of employees. Std. dev. reports the expected deviation from HP-filtered series ($\lambda = 6.25$). The approach is analogous to Burda & Weder (2016). Source: Eurostat government statistics.

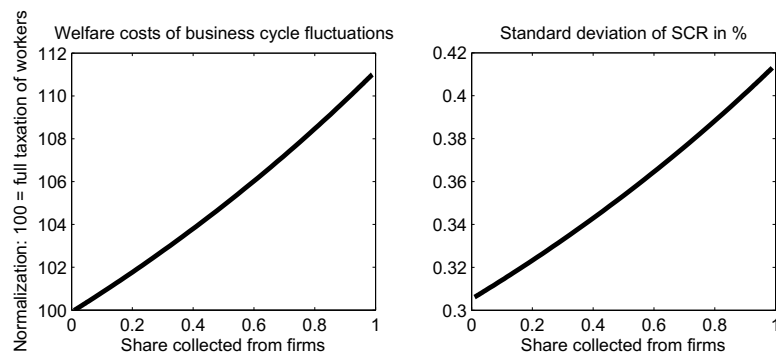


Figure 4.6: Functional form of the dependency of welfare costs and $\sigma(scr)$.

THIRD ESSAY ON LIABILITY-SIDE EQUIVALENCE

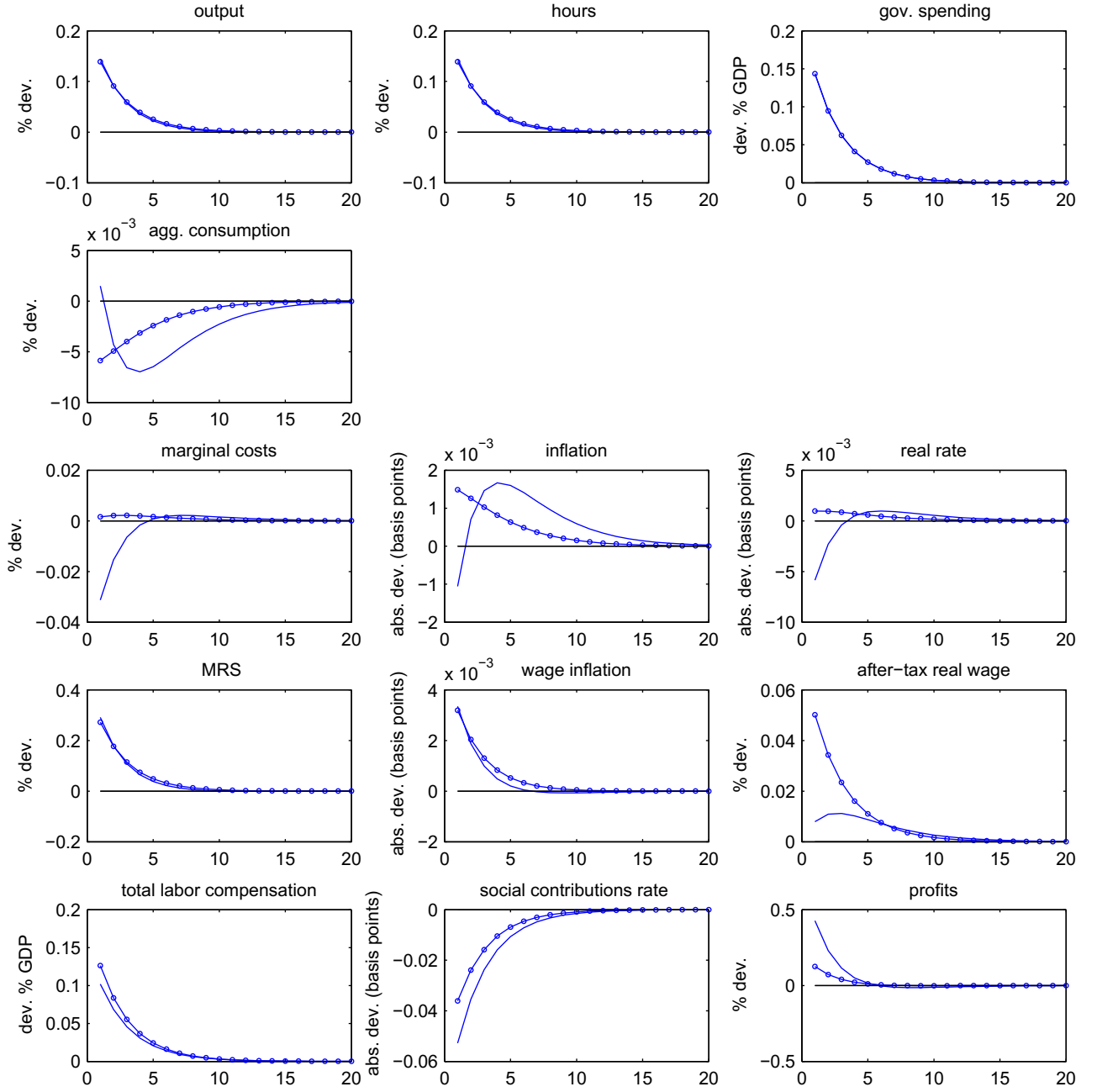


Figure 4.7: Positive one SD government spending shock.
No markers: taxing firms, markers: taxing workers

Bibliography

- Adolfson, M., Laséen, S., Lindé, J., & Villani, M. (2007). Bayesian estimation of an open economy dsge model with incomplete pass-through. *Journal of International Economics*, 72(2), 481–511.
- Anderson, D., Hunt, B., Kortelainen, M., Kumhof, M., Laxton, D., Muir, D., Mursula, S., & Snudden, S. (2013a). Getting to know gimf: The simulation properties of the global integrated monetary and fiscal model. *IMF Working Papers*, 13/55.
- Anderson, D., Hunt, B., & Snudden, S. (2013b). Fiscal consolidation in the euro area: How much can structural reforms ease the pain? *IMF Working Papers*, 13/211.
- Andrle, M., Blagrove, P., Espaillet, P., Honjo, M. K., Hunt, M. B., Kortelainen, M., Lalonde, R., Laxton, M. D., Mavroeidi, E., Muir, D., et al. (2015). The flexible system of global models – fsgm. *IMF Working Papers*, 15/64.
- Arbatli, M. E., Botman, M. D. P., Clinton, K., Cova, P., Gaspar, V., Jakab, Z., Laxton, M. D., Ngouana, M. C. L., & Mongardini, M. J. (2016). Reflating japan: Time to get unconventional? *IMF Working Papers*, 16/157.
- Arnold, J. M., Brys, B., Heady, C., Johansson, Å., Schwellnus, C., & Vartia, L. (2011). Tax policy for economic recovery and growth. *The Economic Journal*, 121(550).
- Barrell, R., Holland, D., & Hurst, I. (2014). Fiscal consolidation: Part 2. fiscal multipliers and fiscal consolidations. *ECB Monthly Bulletin April 2014*.
- Basu, S. & Kimball, M. S. (1997). Cyclical productivity with unobserved input variation. *NBER Working Paper Series*, 5915.
- Bayoumi, T. A. & Eichengreen, B. J. (1994). *One money or many?: Analyzing the prospects for monetary unification in various parts of the world*, volume 76. International Finance Section, Department of Economics, Princeton University Princeton.
- Benedek, D., De Mooij, R. A., Keen, M., & Wingender, P. (2015). Estimating vat pass through. *IMF Working Papers*, 15/214.
- Besley, T. J. & Rosen, H. S. (1998). Sales taxes and prices: An empirical analysis. *NBER Working Paper Series*, 6667.
- Bils, M. & Klenow, P. J. (2004). Some evidence on the importance of sticky prices. *Journal of political economy*, 112(5), 947–985.
- BOP (2011). The impact of a tax change aimed at increasing the external competitiveness of the portuguese economy. *Bank of Portugal Economic Bulletin*, 17(1), 39–42.

BIBLIOGRAPHY

- Boscá, J. E., Domenech, R., Ferri, J., et al. (2012). Fiscal devaluations in emu. *Economic Research Department BBVA Working Paper Series*, 1211.
- Burda, M. C. & Weder, M. (2016). Payroll taxes, social insurance and business cycles. *Journal of the European Economic Association*, 14(2).
- Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary Economics*, 12(3), 383–398.
- Campbell, J. Y. & Mankiw, N. G. (1990). Permanent income, current income, and consumption. *Journal of Business & Economic Statistics*, 8(3), 265–279.
- Carare, A. & Danninger, S. (2008). Inflation smoothing and the modest effect of vat in germany. *IMF Working Papers*, 08/175.
- Carbonnier, C. (2007). Who pays sales taxes? evidence from french vat reforms, 1987–1999. *Journal of Public Economics*, 91(5), 1219–1229.
- Chari, V. V., Kehoe, P. J., & McGrattan, E. R. (2002). Can sticky price models generate volatile and persistent real exchange rates? *The Review of Economic Studies*, 69(3), 533–563.
- Chirakijja, J., Crossley, T., Lührmann, M., & O’Dea, C. (2009). The stimulus effect of the 2008 uk temporary vat cut. *Prepared for: Value-Added Tax: Fiscal and Practical Potential, National Tax Association Annual Meeting 2009*.
- Christoffel, K. P., Coenen, G., & Warne, A. (2008). The new area-wide model of the euro area: a micro-founded open-economy model for forecasting and policy analysis. *ECB Working Paper Series*, 944.
- Coenen, G., Erceg, C. J., Freedman, C., Furceri, D., Kumhof, M., Lalonde, R., Laxton, D., Lindé, J., Mourougane, A., Muir, D., Mursula, S., de Resende, C., Roberts, J., Roeger, W., Snudden, S., Trabandt, M., & in’t Veld, J. (2010). Effects of fiscal stimulus in structural models. *IMF Working Papers*, 10/73.
- Coenen, G., Lombardo, G., Smets, F., & Straub, R. (2007). International transmission and monetary policy cooperation. In *international Dimensions of monetary policy* (pp. 157–192). University of Chicago Press.
- Coenen, G., Mohr, M., & Straub, R. (2008). Fiscal consolidation in the euro area: Long-run benefits and short-run costs. *ECB Working Paper Series*, 902.
- Coenen, G., Straub, R., & Trabandt, M. (2012). Fiscal policy and the great recession in the euro area. *The American Economic Review*, 102(3), 71–76.
- Coenen, G., Straub, R., & Trabandt, M. (2013). Gauging the effects of fiscal stimulus packages in the euro area. *Journal of Economic Dynamics and Control*, 37(2), 367–386.
- Commission, E. (2006). Macroeconomic effects of a shift from direct to indirect taxation: A simulation for 15 eu member states. *Note presented by the EC services at the 72nd meeting of the OECD Working Party No. 2 on Tax Policy Analysis and Tax Statistics, Paris*.
- CPB (2013). Study on the impacts of fiscal devaluation. *European Commission Taxation Papers 36-13*.
- Dalton, H. (1922). *Principles of Public Finance*. George Routledge and Sons, London.
- De Haan, J., Inklaar, R., & Jong-A-Pin, R. (2008). Will business cycles in the euro area converge? a critical survey of empirical research. *Journal of economic surveys*, 22(2), 234–273.

- De Mooij, R. & Keen, M. (2012). Fiscal devaluation and fiscal consolidation: The vat in troubled times. In *Fiscal policy after the financial crisis* (pp. 443–485). University of Chicago Press.
- Dolls, M., Fuest, C., & Peichl, A. (2012). Automatic stabilizers and economic crisis: Us vs. europe. *Journal of Public Economics*, 96(3), 279–294.
- Drautzburg, T. & Uhlig, H. (2015). Fiscal stimulus and distortionary taxation. *Review of Economic Dynamics*, 18(4), 894–920.
- Druant, M., Fabiani, S., Kézdi, G., Lamo, A., Martins, F., & Sabbatini, R. (2009). How are firms' wages and prices linked: Survey evidence in europe. *European Central Bank Working Paper Series*, (1084).
- ECB (2012). *Competitiveness and external imbalances within the euro area*. Technical report, European Central Bank.
- ECB (2014). The role of fiscal multipliers in the current consolidation debate. *ECB Monthly Bulletin December 2012*.
- Eggertsson, G. B. (2011). What fiscal policy is effective at zero interest rates? In *NBER Macroeconomics Annual 2010, Volume 25* (pp. 59–112). University of Chicago Press.
- Eggertsson, G. B. & Woodford, M. (2004). Optimal monetary and fiscal policy in a liquidity trap. In *NBER International Seminar on Macroeconomics 2004* (pp. 75–144).: The MIT Press.
- Erceg, C. J., Henderson, D. W., & Levin, A. T. (2000). Optimal monetary policy with staggered wage and price contracts. *Journal of monetary Economics*, 46(2), 281–313.
- Eurostat (2013). Statistics. Available online at <http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/themes> (accessed on 1.11.2013).
- Evers, M. P. (2012). Federal fiscal transfer rules in monetary unions. *European Economic Review*, 56(3), 507–525.
- Farhi, E., Gopinath, G., & Itskhoki, O. (2014). Fiscal devaluations. *The review of economic studies*, 81(2), 725–760.
- Fatás, A. & Mihov, I. (2009). Why fiscal stimulus is likely to work. *International Finance*, 12(1), 57–73.
- Feenstra, R. C., Luck, P. A., Obstfeld, M., & Russ, K. N. (2014). In search of the armington elasticity. *NBER Working Paper No. 20063*.
- Franco, F. (2010). Improving competitiveness through fiscal devaluation, the case of portugal. *mimeo*.
- Franco, F. (2011). Adjusting to external imbalances within the emu, the case of portugal. *mimeo*.
- Furceri, D. (2010). Stabilization effects of social spending: empirical evidence from a panel of oecd countries. *The North American Journal of Economics and Finance*, 21(1), 34–48.
- Furceri, D. & Mourougane, A. (2010). The effects of fiscal policy on output. *Economics Department Working Papers*, 770.
- Furman, J. (2016). *The New View of fiscal policy and its application*. Technical report, Prepared for the conference Global Implications of Europe's Redesign.
- Galí, J. (2011). *Unemployment fluctuations and stabilization policies: a new Keynesian perspective*. MIT press.

BIBLIOGRAPHY

- Galí, J., Lopez-Salido, J. D., & Valles, J. (2004). Rule-of-thumb consumers and the design of interest rate rules. *Journal of Money, Credit, and Banking*, 36(4), 739–763.
- Galí, J., López-Salido, J. D., & Vallés, J. (2007). Understanding the effects of government spending on consumption. *Journal of the European Economic Association*, 5(1), 227–270.
- Giudice, G., Turrini, A., et al. (2003). Can fiscal consolidations be expansionary in the eu? ex-post evidence and ex-ante analysis. *European Commission Economic Papers*, 195.
- Gomes, S., Jacquinet, P., & Pisani, M. (2010). The eagle. a model for policy analysis of macroeconomic interdependence in the euro area. *ECB Working Paper Series*, 1195.
- Gruber, J. (1997). *The incidence of payroll taxation: evidence from Chile*. Technical report, National Bureau of Economic Research.
- Hebous, S. (2011). The effects of discretionary fiscal policy on macroeconomic aggregates: a reappraisal. *Journal of Economic Surveys*, 25(4), 674–707.
- Hohberger, S. & Kraus, L. (2016). Is fiscal devaluation welfare enhancing? *Economic Modelling*.
- IMF (2011). Addressing fiscal challenges to reduce economic risks. *IMF Fiscal Monitor*.
- IMF (2013). Hungary selected issues. *IMF country report*, 13/86.
- IMF (2014a). Denmark selected issues. *IMF country report*, 14/332.
- IMF (2014b). Spain selected issues. *IMF country report*, 14/193.
- IMF (2015). Iceland selected issues. *IMF country report*, 15/73.
- in't Veld, J. (2013). Fiscal consolidations and spillovers in the euro area periphery and core. *European Commission Economic Papers*, 506.
- Ivanova, A. (2012). Current account imbalances: can structural policies make a difference? (12-61).
- Jones, J., Collins, N., & Sribnick, L. (2012). External influences on business cycle synchronization in the euro area. *International Advances in Economic Research*, 18(1), 28–39.
- Kemmerling, A. (2009). *Taxing the working poor: the political origins and economic consequences of taxing low wages*. Edward Elgar Publishing.
- Kenen, P. B. (1969). The theory of optimum currency areas: An eclectic view. *Monetary Problems of the International Economy*, (pp. 41–60).
- Keynes, J. M. (1931). *Addendum to: Great Britain. Committee on Finance and Industry Report*. Reprinted in Donald Moggridge, *The Collected Writings of John Maynard Keynes*, vol. 20, Cambridge Press for the Royal Economic Society.
- Kim, J. & Kim, S. H. (2003). Spurious welfare reversals in international business cycle models. *Journal of International Economics*, 60(2), 471–500.
- Kimball, M. S. & Shapiro, M. D. (2008a). Labor supply: Are the income and substitution effects both large or both small?
- Kimball, M. S. & Shapiro, M. D. (2008b). Labor supply: Are the income and substitution effects both large or both small? *NBER Working Paper Series*, 14208.

- Kormilitsina, A. & Nekipelov, D. (2012). Approximation properties of laplace-type estimators. In *DSGE Models in Macroeconomics: Estimation, Evaluation, and New Developments* (pp. 291–318). Emerald Group Publishing Limited.
- Koskela, E. & Schöb, R. (1999). Does the composition of wage and payroll taxes matter under nash bargaining? *Economics Letters*, 64(3), 343–349.
- Kosonen, T. (2013). More haircut after vat cut? on the efficiency of service sector consumption taxes. *Government Institute for Economic Research Working Papers*, 49.
- Kumhof, M., Muir, D., Mursula, S., & Laxton, D. (2010). The global integrated monetary and fiscal model (gimf)–theoretical structure. *IMF Working Papers*, 10/34.
- Lan, H. & Meyer-Gohde, A. (2013). Solving dsge models with a nonlinear moving average. *Journal of Economic Dynamics and Control*, 37(12), 2643–2667.
- Leeper, E. M., Traum, N., & Walker, T. B. (2015). Clearing up the fiscal multiplier morass: Prior and posterior analysis. *NBER Working Paper Series*, 21433.
- Lehmann, E., Marical, F., & Rioux, L. (2011). Labor earnings respond differently to income-tax and to payroll-tax reforms.
- Lipinska, A. & Von Thadden, L. (2012). On the (in) effectiveness of fiscal devaluations in a monetary union. *Board of Governors of the Federal Reserve System: Finance and Economics Discussion Series 2012-71*.
- Lucas, R. E. (1987). *Models of business cycles*, volume 26. Basil Blackwell Oxford.
- Lucas, R. E. (2003). Macroeconomic priorities. *American Economic Review*, 93(1), 1–14.
- McKinnon, R. I. (1963). Optimum currency areas. *The American Economic Review*, (pp. 717–725).
- Mian, A. & Sufi, A. (2010). Household leverage and the recession of 2007–09. *IMF Economic Review*, 58(1), 74–117.
- Mieszkowski, P. M. (1967). On the theory of tax incidence. *The Journal of Political Economy*, (pp. 250–262).
- Monacelli, T. (2005). Monetary policy in a low pass-through environment. *Journal of Money, Credit & Banking*, 37(6).
- Mundell, R. A. (1961). A theory of optimum currency areas. *The American Economic Review*, (pp. 657–665).
- Papageorgiou, D. (2012). Fiscal policy reforms in general equilibrium: The case of greece. *Journal of Macroeconomics*, 34(2), 504–522.
- Parker, J. A. (2011). On measuring the effects of fiscal policy in recessions. *Journal of Economic Literature*, 49(3), 703–718.
- Picard, P. & Toulemonde, E. (2001). On the equivalence of taxes paid by employers and employees. *Scottish Journal of Political Economy*, 48(4), 461–470.
- Pike, R., Lewis, M., Turner, D., et al. (2009). Impact of vat reduction on the consumer price indices. *Economic and Labour Market Review*, 3(8), 17–21.

BIBLIOGRAPHY

- Politi, R. B. & Mattos, E. (2011). Ad-valorem tax incidence and after-tax price adjustments: evidence from brazilian basic basket food. *Canadian Journal of Economics/Revue canadienne d'économie*, 44(4), 1438–1470.
- Poterba, J. M. (1996). Retail price reactions to changes in state and local sales taxes. *National Tax Journal*, (pp. 165–176).
- Ramey, V. A. (2011). Can government purchases stimulate the economy? *Journal of Economic Literature*, 49(3), 673–685.
- Rasmussen, B. S. (1998). Long run effects of employment and payroll taxes in an efficiency wage model. *Economics Letters*, 58(2), 245–253.
- Ratto, M., Roeger, W., & in't Veld, J. (2009). Quest iii: An estimated open-economy dsge model of the euro area with fiscal and monetary policy. *economic Modelling*, 26(1), 222–233.
- Roeger, W. & in't Veld, J. (2010). Fiscal stimulus and exit strategies in the eu: a model-based analysis. *European Commission Economic Papers*, 426.
- Schmitt-Grohé, S. & Uribe, M. (2003). Closing small open economy models. *Journal of international Economics*, 61(1), 163–185.
- Schmitt-Grohé, S. & Uribe, M. (2007). Optimal simple and implementable monetary and fiscal rules. *Journal of monetary Economics*, 54(6), 1702–1725.
- Snudden, S. & Klyuev, M. V. (2011). Effects of fiscal consolidation in the czech republic. *IMF Working Papers*, 11/65.
- Stiglitz, J. (2000). *Economics of the Public Sector*. Norton.
- Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester conference series on public policy*, 39, 195–214.
- Vegh, C. A. & Vuletin, G. (2015). How is tax policy conducted over the business cycle? *American Economic Journal: Economic Policy*, 7(3), 327–370.
- Weber, M. & Schram, A. (2013). The non-equivalence of labor market taxes: A real-effort experiment.
- Wendler, M., Tremml, B., & Buecker, B. J. (2008). *Key aspects of German business law: a practical manual*. Springer Science & Business Media.
- WorldBank (2013). World databank. Available online at <http://databank.worldbank.org/data/home.aspx> (accessed on 28.10.2013).

Selbständigkeitserklärung

Ich bezeuge durch meine Unterschrift, dass meine Angaben über die bei der Abfassung meiner Dissertation benutzten Hilfsmittel, über die mir zuteil gewordene Hilfe sowie über frühere Begutachtungen meiner Dissertation in jeder Hinsicht der Wahrheit entsprechen.

Simon Voigts